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ABSTRACT

These instructional materials provide eight lessons on print reading as applied to the machine shop course. Introductory materials include a list of the objectives and activities for each competency, a list of references, a student progress record, and a keyed copy of a pretest. The lessons cover the role of technical drawing in society; conventional lines; multi-view drawing or orthographic projection; abbreviations, dimensions, notes, and symbols in reading a print; sectional views; auxiliary views; orthographic sketching; and pictorial sketching. Additional lessons are provided on bolt patterns, gears, and assembly drawing. Each lesson consists of an informational section (subject, aim, teaching aids, materials, references, prerequisite experience of learner, and content outline with preparation/motivation, presentation of information, application/student activities, verification and/or evaluation, summary, suggested student reading), a copy of the information sheet contained in the student assignment book, and keyed copies of the student assignment sheets and test. A glossary is appended. (YLB)

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MACHINE SHOP

BLOCK II

PRINT READING

PRINTED 1983

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PREFACE

Since the beginning of time civilization has been confronted with the problem of communication. The expression of thoughts and ideas has taken many forms such as verbal languages, audio-visual media, art, and music. One of the most important advancements in communication has been through the development of technical drawing, which is the guidepost to industry.

Today the role of the machinist in our industrial society requires the ability to accurately read and interpret industrial prints. In addition, the ability of the machinist to convey an idea through freehand sketching is of significant value. Much of today's machinist force in industry comes from vocational industrial programs, such as the public school, private school, or a company's apprenticeship program. Therefore, it is the responsibility of the instructor to provide training in print reading that will properly prepare the student to accurately read and interpret those prints used in industry, as well as providing training in the operation and use of tools and machines used.

The intent of these lessons is to provide the instructor with a tool for teaching the basics required in print reading. This is accomplished by providing lessons for the teacher on various print reading topics with transparencies to complement each lesson. In addition, an assignment book has been provided for the student to include information sheets, assignment sheets, and a test over each lesson.

The scope of these lessons is to provide the basic requirements to the student with additional assignments that the instructor may wish to use if so desired.

OBJECTIVES OF PRINT READING

The objectives and competencies listed below are to be considered significant in the teaching of print reading as applied to the machine shop course. To insure complete attainment of these competencies, a variety of activities are identified for each competency to be attained. Every effort is made to incorporate these activities into the study of Print Reading. Instructors are encouraged to add additional objectives and activities as a means of enriching their program.

STUDENT COMPETENCIES	ACTIVITIES TO ACHIEVE COMPETENCIES
Identify the role of technical drawing in our society	1. Provide student with information sheet on the development of technical drawing 2. Discuss early means of graphic communication 3. Provide samples of prints common to industry 4. Discuss the significance of technical drawing to the machinist
Identify, interpret, and draw conventional lines used in technical drawing	1. Provide student with information sheet on "The Alphabet of Lines" 2. Discuss types and uses of lines 3. Provide student with assignments on conventional line identification, application, and method of drawing
Visualize and interpret an object graphically through various views	1. Provide student with information sheet on the principles of orthographic projection 2. Explain and discuss the relationship of views 3. Have student identify the planes of projections 4. Require student to identify the regular views of an object 5. Have student identify principle dimensions of an object 6. Provide student with assignments on visualization of orthographic views 7. Provide student with assignments on visualization of parts in special views 8. Provide student with assignment on sketching or drawing the views of an object
Read and record information taken from a print	1. Provide student with information sheet on symbols, abbreviations, notes, and dimensioning practices used in technical drawing 2. Explain and discuss information given on a drawing and how it is given

STUDENT COMPETENCIES	ACTIVITIES TO ACHIEVE COMPETENCIES
	3. Provide student with assignment on reading and recording information given on a drawing 4. Provide student with assignment on applying notes and dimensions on a drawing 5. Test student on notes, abbreviations, and symbols used in technical drawings
Exhibit skill in sketching and maintaining good proportion	1. Provide student with information sheet on sketching techniques 2. Provide student with information sheet on orthographic and pictorial sketching 3. Demonstrate sketching procedures 4. Discuss application and types of sketches 5. Discuss proportion and methods of obtaining proportion 6. Provide student with assignment sheet on sketching, both orthographic and pictorial 7. Provide opportunity for student to plan and design a project
Expand technical vocabulary	1. Provide glossary of terms common to the machinist trade and print reading 2. Require student to define terms
Display skill in mathematics	1. Require student to determine tolerances and allowances 2. Have student display skill in converting, adding, subtracting, multiplying, and dividing decimals and fractions as they apply to the print

PLAN OF INSTRUCTIONS

These instructional materials include eight lessons in a logical order of learning. The lessons include the theory of orthographic projection and the relationship of views; conventional lines, symbols, abbreviations, and notes recommended by the American Standards Association; special views, such as auxiliary and sectional views; and dimensioning practices as used in machine prints. Additional lessons in technical sketching are included in order to develop skills in making a clear and accurate sketch. Although the material is developed in a logical manner, the instructor is urged to add to it, delete from it, or use it in a sequence that better fits the individual program.

Each lesson of the instructor's material consists of an informational lesson (I) supplemented by a set of transparencies which are available; a copy of the information sheet (IS) that is contained in the student's assignment book; and a keyed copy of the student's assignment sheet (AS) and test (T).

The student assignment book, Print Reading For Machine Shop, which is available, consists of information sheets with one or more assignment sheets and a test for each lesson. In the appendix are a glossary of terms common to the machinist trade

Additional assignment sheets relating to special machining operations, such as gears, assemblies, and hole patterns are provided in section II-D of the assignment book. These assignment sheets contain information sheets and may be assigned as the instructor desires. Extra sheets for sketching are also included to be used for additional problems or the student's selected problems as the instructor may assign.

Student assignments consist of drawing assignments selected to give the student an opportunity to learn and apply the principles of orthographic projection and pictorial presentation as well as other drafting practices; and to develop skill in making a simple drawing and applying dimensioning practices.

Print reading assignments provide the student with the opportunity to read and interpret a print that is common to machine prints and make application of the basic principles of mathematics used daily in the shop.

Each student assignment book contains a record of assignment progress sheet so as to maintain a record of the assignment and date assigned and the completion date with the student's score. The method of scoring the student's work and length of time to complete the work is left to the discretion of the instructor.

REFERENCES
FOR
PRINT READING FOR MACHINE SHOP

The following references are listed as a source of information used in the development of the lessons on print reading and the student assignment book. They may be considered as a supplement for the teacher and the student.

1. Coover, Shriver L., Drawing and Blueprint Reading, McGraw-Hill Book Company, Dallas, Texas

2. Giesecke, Fredrick E., Mitchell, Alva, Spencer, Henry C., and Hill, Ivan L., Technical Drawing, Fifth Edition, The Macmillan Company, New York, New York

3. Hardman, William E., Blueprint Reading For Metalworking Trainees, Third Edition, National Tool, Die and Precision Machining Association, 9300 Livingston Road, Washington D.C. 20022

4. Ihne, Russel W. and Streeter, Walter E., Machine Trades Blueprint Reading, Sixth Edition, American Technical Society, Chicago, Illinois 60637

5. Olive, C. Thomas and Payne, Albert V., Basic Blueprint Reading For Machine Shop, Delmar Publishers, Inc., Albany, New York 12205

6. Spence, William P., Drafting Technology and Practice, Charles A. Bennett Co., Inc., Peoria, Illinois 61614

STUDENT PROGRESS RECORD
FOR
PRINT READING FOR METAL TRADES

The Student Progress Record contains the title and number of each assignment and test. Space has been provided for:

1. Record of the date the assignment was made by instructor
2. Record of the completion date of each assignment
3. Record of grade or rating for each assignment or test

The student will keep a record of each assignment or test, thereby providing an accurate record of work assigned, completed, and grade achieved. This will give both student and instructor a record of the student's progress.

ASSIGNMENT NUMBER	SUBJECT OR TOPIC	Date Assigned	Date Completed	Grade/ Rating
II-A-1(AS)	History of Technical Drawing			
II-A-1(T)	Test			
II-B-1(AS)	Conventional Lines of Drawing			
II-B-1(T)	Test			
II-B-2(AS)	Multi-View-Missing Lines # 1			
II-B-2 (AS)	Multi-View-Missing Lines # 2			
II-B-2a(AS)	Multi-View-Three Views # 3			
II-B-2a(AS)	Multi-View-Three Views # 4			
II-B-2(T)	Test			
II-B-3(AS)	Dimensions, Notes and Symbols			
II-B-3a(AS)	Abbreviations, Notes and Symbols			
II-B-3(T)	Test			
II-B-4(AS)	Identify and Complete Sectional Views			
II-B-4a(AS)	Print Reading - Sectional Views # 1			
II-B-4a (AS)	Print Reading - Sectional Views # 2			
II-B-4(T)	Test			
II-B-5(AS)	Print Reading - Auxiliary Views # 1			
II-B-5(AS)	Print Reading - Auxiliary Views # 2			
II-B-5(T)	Test			
II-C-1(AS)	Sketch - Straight Lines # 1			

ASSIGNMENT NUMBER	SUBJECT OR TOPIC	Date Assigned	Date Completed	Grade/ Rating
II-C-1(AS)	Sketch - Curved Lines # 2			
II-C-1a(AS)	Sketch - Missing Views # 1			
II-C-1a(AS)	Sketch - Missing Views # 2			
II-C-1a(AS)	Sketch - Three Views # 3			
II-C-1a(AS)	Sketch - Three Views # 4			
II-C-1a(AS)	Sketch - Three Views # 5			
II-C-1(T)	Test			
II-C-2(AS)	Pictorial Sketch - Isometric # 1			
II-C-2(AS)	Pictorial Sketch - Isometric # 2			
II-C-2(AS)	Pictorial Sketch - Oblique # 3			
II-C-2(AS)	Pictorial Sketch - Oblique # 4			
II-C-2(T)	Test			
II-D-1(AS)	Bolt Patterns			
II-D-2(AS)	Gears			
II-D-3(AS)	Assembly Drawing			
Pre-Test	Print Reading			

PRINT READING

PRE-TEST

MATCHING TEST

Name _____ Date _____

Directions: One statement from Column I is closely related with an item in Column II. Place the capital letter of the associated term in Column II in the blank space at the left of the number of Column I.

Example: B 1. Mounted on an aperture card

A. Print
B. Microfilm
C. Ammonia

O	1. Represents invisible edges	A. Tolerance
K	2. Gives distance between two edges	B. FOA
R	3. Total indicator reading	C. 2B
A	4. Permissible variation in size	D. 2.756
P	5. Relationship of normal views with each other	E. CSK
B	6. Finish all over	F. C'Bore
C	7. Class of internal thread fit	G. Degrees
E	8. Countersink	H. Print
L	9. Locates hole center	I. ✓
G	10. Angle measurement	J. Parallel
D	11. Lower limit of 2.758 ± .002	K. Dimension line
Q	12. Bolt circle	L. Center line
F	13. Enlarge end of hole cylindrically	M. Leader line
H	14. Duplication of an original	N. 2.760
I	15. Machined surface	O. Hidden line
		P. Perpendicular
		Q. BC
		R. TIR

ONE RIGHT ANSWER MULTIPLE CHOICE TEST

Directions: Each of the following statements is followed by four answers. Only one of these answers is correct. Read each statement carefully and select the correct answer. Place the letter of the answer selected in the corresponding blank space in the right hand column.

Example: 1. The reproduction of an original drawing is a/an: C

a. sketch
b. work drawing
c. print
d. duplication

1. The true shape and size of an object is provided in a/an: B

a. isometric drawing
b. multi-view drawing
c. assembly drawing
d. pictorial drawing

2. The number of normal views of an object is: A

a. six
b. four
c. three
d. two

3. The views most frequently selected for a work drawing are: C

a. left side, right side, top
b. front, top, bottom
c. front, right side, top
d. front, left side, top

4. Internal features are simplified by use of a/an: D

a. auxiliary view
b. pictorial view
c. assembled view
d. sectioned view

5. In the thread note 5/8-18-UNF-2A, the 18 represents: C

a. size of thread
b. class fit
c. threads per inch
d. type of thread

6. An enclosed informational area used to provide the name of the part and other supplemental information is the: B

a. specifications
b. title box
c. bill of materials
d. heading

7. Spotfacing is used to: D

a. provide clearance for wrench
b. provide smooth overall finish
c. provide recess for bolt
d. provide flat surface for nut or screw head

8. Auxiliary views are used to represent: B

a. hidden surfaces
b. slanted surfaces
c. assembled parts
d. gears

9. In the note 1/2" drill, 3/4" C'Bore - 3/8" deep, 2 holes, the counterbore hole depth is: A

a. 3/8"
b. 1/2"
c. 3/4"
d. not given

10. A part with a given dimension of 6 3/4" ± 1/64" would be acceptable if it measured between: C

a. 6 3/4" - 6 7/8"
b. 6 21/64" - 6 25/64"
c. 6 47/64" - 6 49/64"
d. 6 23/32" - 6 25/64"

11. A print that indicates correct position and proper location of parts in relation to each other: C

a. work drawing
b. detailed drawing
c. assembly drawing
d. sketch

12. Information that applies to a specific operation: A

a. local notes
b. general notes
c. specification
d. dimensions

13. Information that applies to an entire drawing: B

a. local news
b. general notes
c. specification
d. dimensions

14. The maximum size of a shaft whose dimension is 2.691" ± .002": D

a. 2.689"
b. 2.6908"
c. 2.6912"
d. 2.693"

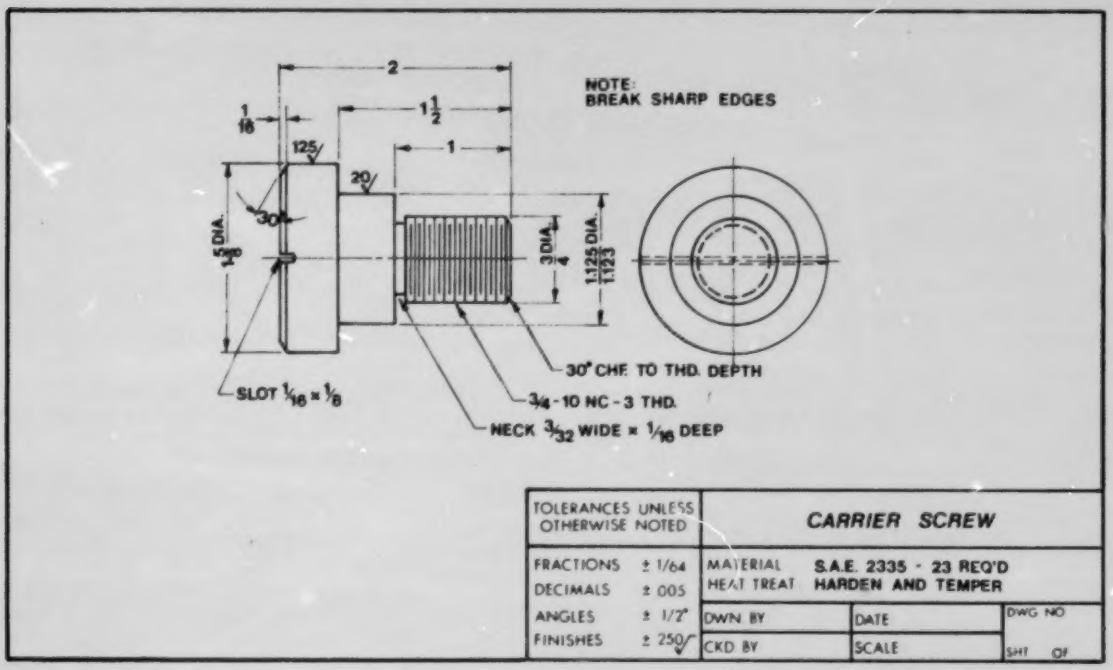
15. Reveals the interior of a part: C

a. auxiliary view
b. isometric sketch
c. sectioned view
d. oblique drawing

PICTORIAL RECALL TEST

Directions: Study the given print and complete each statement with the answer that will make the statement correct.

Example: 1. The order number for the part is _____. 82-124



1. The name of the part is _____. Carrier Screw
2. The thread diameter is _____. 3/4"
3. The slot size is _____. 1/16" x 1/8"
4. A _____ finish is specified for the screw head. 125
5. A total of _____ pieces are to be made. 23
6. The maximum diameter of the screw head is _____. 1 41/64"
7. The minimum diameter of the shoulder is _____. 1.123"
8. A chamfer of _____ is cut to thread depth. 30°
9. A _____ finish is called for on the shoulder. 20
10. The part is to be made from _____ material. SAE 2335
11. The heat treatment process to be applied upon completion will be _____ and _____. Hardened/Tempered
12. The size of the thread relief is _____. 3/32" x 1/16"
13. The length of the shoulder is _____. 1/2"

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

II-A-1(I)

SUBJECT: Drawing - The Universal Graphic Language

AIM: The student will know the significant role technical drawing plays in this industrialized society and the importance of the ability to read and interpret drawings that are common to the machinist trade.

TEACHING AIDS: Samples of prints
Sample of a machined part with print
Information Sheet: II-A-1(IS) "Drawing - The Universal Graphic Language"

MATERIALS: Chalkboard, overhead projector and screen

REFERENCES: Drawing and Blueprint Reading, Coover, Shriver L., McGraw-Hill Book Company, Dallas, TX
Basic Blueprint Reading and Sketching, Olive, C. Thomas and Payne, Albert V., Delmar Publishers, Inc., Albany, N.Y. 12205
Print Reading For Machine Shop, Vocational Instructional Services, Texas A&M University, F. E. Box 182, College Station, TX 77843

PREREQUISITE EXPERIENCE OF THE LEARNER: The student must be enrolled in class and must exhibit a desire to learn. Additional prerequisites that are desirable but are not required are previous experiences in drawing and mathematics.

I. PREPARATION (OF THE LEARNER - MOTIVATION)

Today in our industrialized society, production processes are a way of life. Products are mass manufactured at various places and assembled together. Parts are manufactured to interchange with other parts. How is this made possible? What is the key to quality control that provides the machinist with information that permits the machining of parts that will meet the needs and specifications to be used with other parts? The answer to this lies in the use of a universal graphic language called technical drawing or, as commonly referred to, prints. It is by the use of technical drawings that complex parts may be described with such completeness and accuracy that any number of parts can be manufactured to a specific size and shape.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Universal Graphic Language	1. Present the question "What do we mean by universal graphic language?" a. Graphic language refers to communicating or relating technical information through the use of drawings

b. Universal means that it is a language that is understood throughout the world

2. Discuss ways that technical drawing is applied to the manufacturing and building industry
   a. Design for the manufacture and assembly of products
   b. Architectural design for homes and commercial buildings
   c. Maps
   d. Charts
   e. Production illustrations
3. Show an example of a drawing
   Note: Show original and/or a print
   Explain the difference
4. Show the manufactured part of the drawing viewed
5. Explain that a drawing is a language consisting of the following items
   a. Alphabet of lines
   b. Views that have a specific relationship with each other
   c. Various types of drawings that have a specific purpose
      Note: Give an example of one, such as the assembled drawing
   d. Dimensions, notes, and symbols
      Note: Point out each specific item as they are mentioned
6. Show an example of a foreign drawing and compare it with an American print
   Note: Point out the major differences and the similarities

B. History of Technical Drawing

1. Developed as a means of communicating thoughts from one person to another
2. Earliest record goes back to cave-dwellers' drawings on walls
3. First written evidence of technical drawing was 30 B.C.
4. Evidence of the use of technical drawings found in structures still remaining today
   a. Pyramids
   b. Circus Maximus of Rome
   c. Temple of Amon in ancient Egypt completed in 980 B.C.

5. Original drawings were used until 1876
6. Blueprint process was introduced in the United States at the Philadelphia Centennial Exposition in 1876

C. Purpose of Technical Drawing

1. Provides complete and precise information about a part for the people responsible for producing, building, or assembling the part
2. Provides information by
   a. Indicating the true shape of the part through the use of the alphabet of lines
   b. Gives the exact size of the part by giving dimensions
   c. Provides instructions necessary to produce the part by the use of symbols, notes, and specifications

D. Stages of the Drawing-Design to Product

The drawing follows many stages of use and development from the drawing board to the finished product. These include:

1. Design department as an idea expressed by the designer in the form of a sketch
2. Engineering department where the design is studied from the standpoint of feasibility, efficiency, economics, and usefulness
3. Materials control department determines material requirements and availability
4. Purchasing department obtains information on economics of procuring part elsewhere or producing the part
5. Tooling department determines in minute detail the equipment, tooling, and method to be used in manufacturing parts and maintaining quality control
6. Diemaking department will make the dies or patterns required for forming, shaping, or casting the part where necessary
7. Production department regulates and controls production process
8. Quality control department compares finished product with drawing to ascertain that parts meet precise specifications and requirements
9. Assembly department assembles multi-part products according to the assembly drawing

E. Types of Drawing

1. Sketch
   a. A preliminary idea
   b. Rough sketch of a part
      Note: Common to the small independent shop
   c. Made by freehand sketching

Show: Sample of Drawings

2. Design layout or sketch
   a. Drawn accurately with instruments
   b. Actual sizes and proportions are determined
   c. Methods, materials, and costs are considered in design
3. Work drawing (production drawing)
   a. Multi-view drawing
   b. Necessary views are drawn
   c. Information necessary for production of part provided
   d. Part is viewed in true shape in different views
4. Pictorial drawings
   a. Three demensional picture of part
   b. Enable non-technical persons to visualize part
   c. Enable designer to visualize part in various stages
   d. Viewed as picture in catalog
5. Assembled drawing
   a. Shows the assembly of a multi-piece part
   b. Used by the assembly department

F. Drawing Reproduction

1. Method of duplicating the original without redrawing
2. Commonly referred to as "blueprint" or, as presently called, "print"

Note: The term blueprint derived from prints with white lines and blue background

1. Purpose

1. Protects original drawing
2. Simplifies storage and filing
3. Efficient method of distribution of prints
4. Economical method of making changes or additional copies

2. Process

1. Original drawing is made on a special paper or cloth that is translucent or transparent (will pass light)

   Note: Referred to as tracing paper or cloth

2. Print is made on sensitized paper when exposed to light
   Note: Light burns out sensitive coating on paper except where surface is protected by opaque lines of the original drawing
3. Sensitized paper is exposed to developing agent, such as ammonia
   Note: Developing agent may be liquid, moist, or dry (vapor)
4. Prints may be:
   a. White background with blue, black, or other colored lines
   b. Blue background with white lines
5. Prints are made by various methods
   Note: All have a similar process
   1. Diazo moist and dry process
   2. Thermo-fax
   3. Verifax
   4. Xerographic
   5. Microfilm
      a. Security
      b. Small filing space
      c. Large drawings or large number of drawings
      d. Mounted on aperture cards
      e. Viewed in a reader
6. Print sizes
   a. Size A - 8½" x 11"
   b. Size B - 11" x 17"
   c. Size C - 17" x 22"
   d. Size D - 22" x 34"
   e. Size E - 34" x 44"
   f. Size R - All sizes beyond E

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION).

1. Students examine various prints
2. Students compare foreign prints with prints developed in the United States
3. Have students list the stages of the prints used in the production of a part
4. Students discuss the various types of drawings and their uses

5. Students compare various methods of making prints

6. Students discuss the advantages in reproduction of original drawings

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENTS' COMPREHENSION OF MATERIALS PRESENTED).

Essay Questions

1. The work drawing conveys information by giving the:

Answer:
1. True size of the part
2. True shape of the part
3. Instructions pertaining to the manufacturing process

2. Drawing is a language that gives information through the use of:

Answer:
1. Specific lines that have a specific meaning
2. Dimensions
3. Notes and symbols
4. Abbreviations
5. Views of multiple projection
6. Various types of drawings

3. List the various stages in the use of a drawing from the design to the finished product.

Answer:
1. Designing department
2. Engineering department
3. Materials control department
4. Purchasing department
5. Tooling department
6. Diemaking department
7. Production department
8. Quality control department
9. Assembly department

4. The process of making a print from an original drawing consists of:

Answer:
1. Exposing the original drawing and sensitized paper to light
2. Exposing the sensitized paper to a developing agent

5. The advantages of making a print are:

Answer:
1. Protection
2. Simplifies storage and filing
3. Efficient method of distribution
4. Economical method of reproducing and making changes

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT).

Drawing is a universal graphic language that is used to convey an idea or thought by the use of specific lines that have special meanings and are drawn a specific way; abbreviations and symbols; notes; and various views placed in a certain relationship with each other in order to completely describe the size and shape of an object. The term "universal graphic language" means that with exception of the language that notes or dimensions are given in, everything else is basically the same in meaning throughout the world. As the language of industry and science, technical drawing ranks next to the basics: reading, writing, and arithmetic. Because of their role in the manufacturing field, it is essential that the machinist be capable of reading and interpreting the drawings required of the trade.

Types of drawings common to the machinist trade are:

1. Preliminary sketches (rough sketch)
2. Design layout or sketch
3. Work drawings (production drawings)
4. Pictorial drawings
5. Assembled drawings

Prints are reproductions of original drawings. The term print was originally blueprint because the print background was blue with white lines.
Prints are important because they:

1. Protect against damage to the original drawing
2. Simplify storage
3. Provide economical and efficient method of distributing copies of the original
4. Permit changes to be made more economically

The process of making a print consists of two steps:

1. Exposing the original drawing and a sensitized paper to light
2. Developing the exposed sensitized paper to a developing agent such as ammonia vapors

SUGGESTED READING FOR THE STUDENT:

II-A-1(IS) "Drawing - The Universal Graphic Language"

The Next Lesson Is: II-B-1(I) "Alphabet of Lines"

INFORMATION SHEET
ON
PRINT READING

II-A-1(IS)

SUBJECT: Drawing The Universal Graphic Language

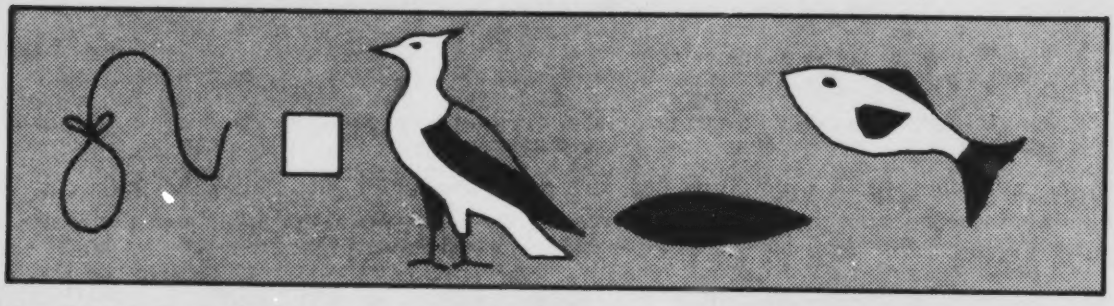
INTRODUCTORY INFORMATION:

The term "universal graphic language" refers to the many ways technical information is communicated through the use of drawings or pictures. The word "universal" refers to the worldwide use of this graphic language that is common to all nations. The development and use of this graphic language parallels and complements the development of industry and our modern way of life.

GENERAL INFORMATION

Early History of Drawing

What type of communication was used in the early development of civilization? It is difficult for us to visualize a society without verbal communications, theaters, newspapers, books, and many other means of communication that are available to us today. If we were to turn back history some 35,000 years or more, we would find a form of written communication known as the Egyptian Hieroglyphics. It was a form of picture writing that portrayed characters, such as animals.



A much later evidence of the use of drawings can be found in the pyramids of Egypt, 3733 B.C., the Roman buildings and structures, not to exclude the most famous Circus Maximus of Rome, commonly referred to as the Roman Coliseum, or the Parthenon of Athens, Greece, 490 B.C. None of these structures could have been built without the assistance of a plan or drawing. As today, this required people who could draw the plan and people who could read the plan in order to carry out the task of seeing that the building was correctly built. Today, we have draftsmen and designers to make the drawings and skilled workers who read and interpret the drawing and manufacture the product.

As civilization progressed and industry developed, the development of the graphic language has kept pace with the increasing needs and demands of industry. Processes,

procedures, and methods are constantly changing, but the purpose and need for people to be able to read, interpret, and manufacture products as designed remains the same as some 3,000 years ago.

The Graphic Language

The term "graphic language" refers to the means of communicating through the use of pictures or drawings. Through many years of development, this graphic language has expanded to include many different methods of providing technical information through use of pictures. As an old Chinese proverb states, "One picture is worth one thousand words."

Modern technology requires many different types of drawings. Some of which are:

1. Design drawings for the manufacture and assembly of products
2. Architectural plans for the design of homes and commercial buildings
3. Production illustrations or pictorial drawings used to present technical information, such as assembled drawings or shaded drawings in a simple way.
4. Charts used to show technical data in a simplified way. Common uses are: production charts, safe work days, profit gains, and losses
5. Maps, such as survey maps, road maps, and plant maps
6. Development drawings that are used in the sheetmetal industry for giving shape to flat material to be cut and formed

Regardless of the type or use of a drawing, its sole purpose is to provide complete and accurate information. In design drawings, such as those used in the machine shop, it is very essential that the drawing gives the following information accurately:

1. The true shape of the part
2. The exact size
3. Information concerning materials, production procedures, and specifications

In the manufacture of a new product, the design or print will travel to various departments before the product is completed. The various stages or departments involved are:

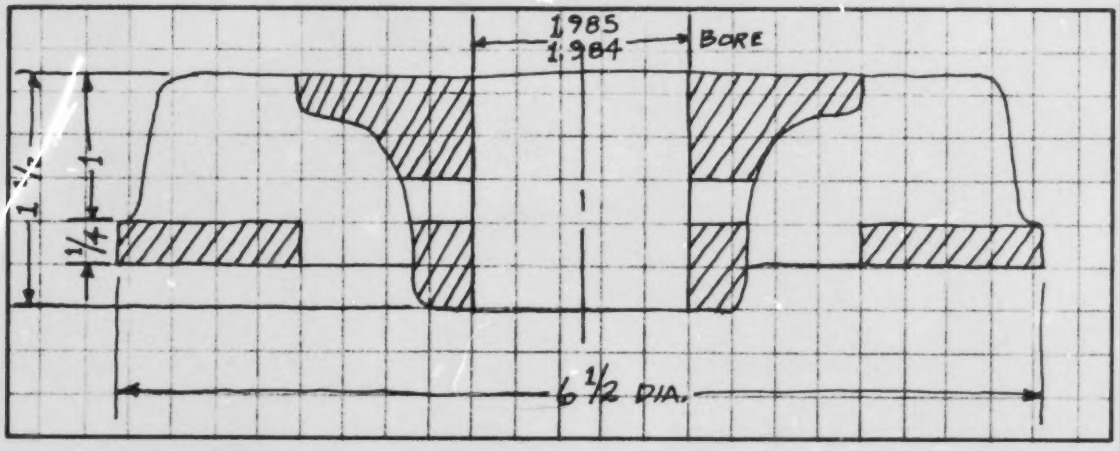
1. Design Department where the design begins in the form of an idea and sketch
2. Engineering Department for the study of economy, feasibility, usefulness, and efficiency
3. Materials Department where materials requirements and availability are determined
4. Tooling Department for the determination of required tooling and production procedures
5. Production Department where the production processes and regulations are controlled
6. Quality Control Department where the finished product is compared with the drawing to ascertain that all specifications and requirements are met

7. Assembly Department for the assembly of multi-part products according to the assembly drawing

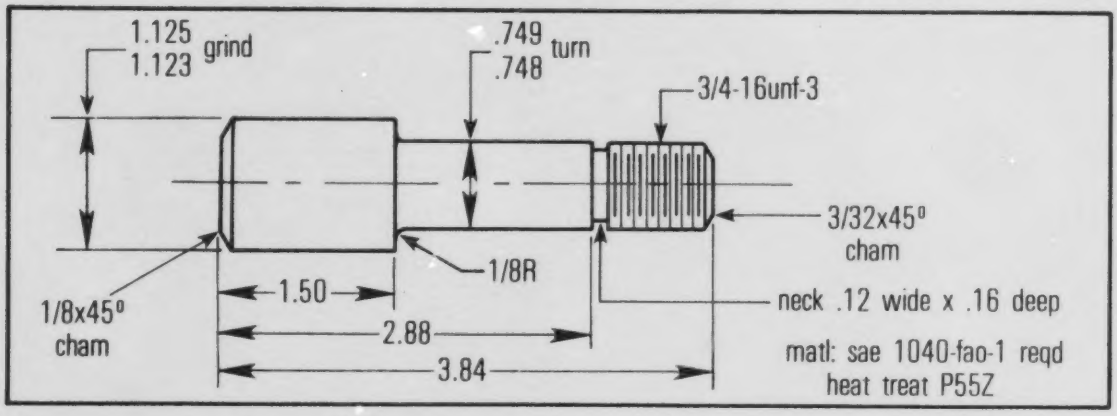
It is within these stages of development that the product is made or manufactured. The responsibility lies with the skilled machinist to take the drawing and produce the part to the specifications required. To do this requires not only skill in the operation of machine tools but proficiency in the reading and interpretation of the drawing or print.

There are various types of drawings used in industry today. The way the drawing is made is determined by the use of the drawing. Drawing representations common to the machinist trade include the following:

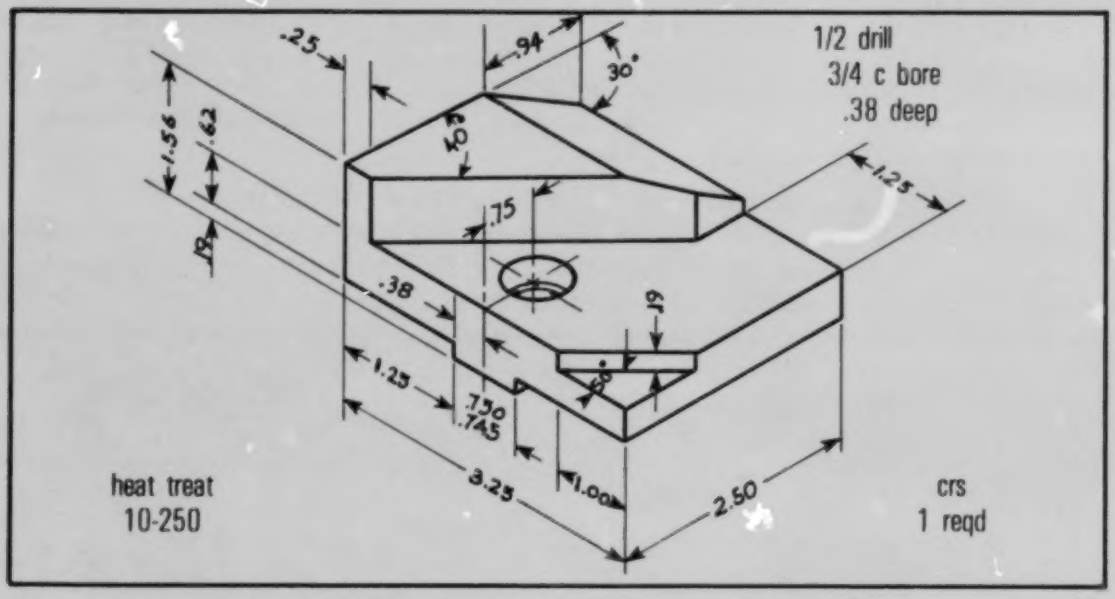
1. Rough sketch - This type of drawing is a freehand sketched drawing normally used to present an original idea from which the work drawing is made. In small machine shops, the machinist frequently uses this type of drawing to interpret the needs of a customer, as in Figure 1.



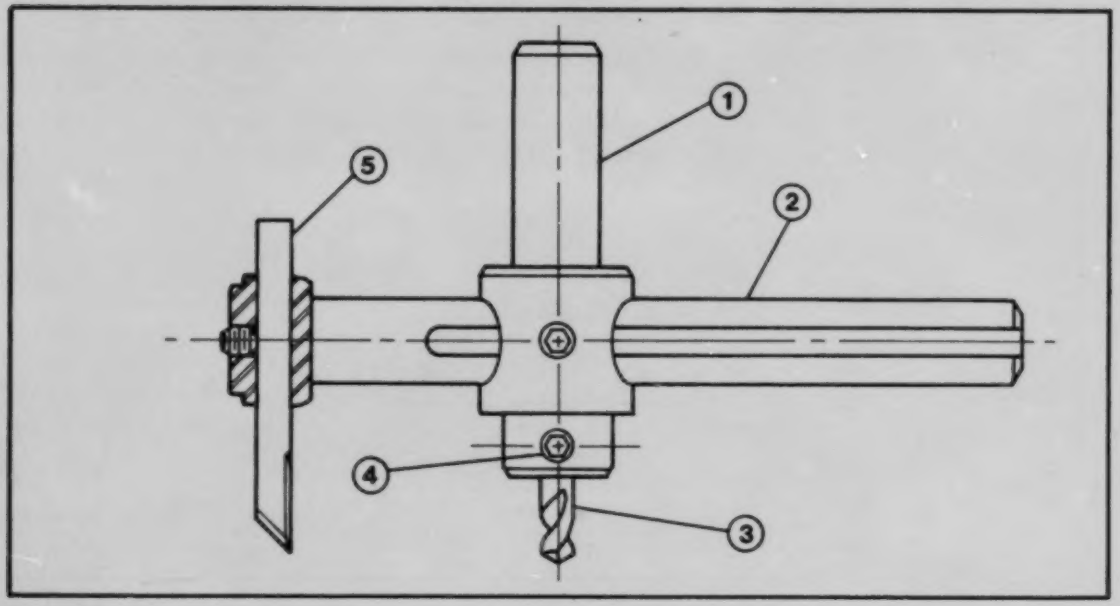
2. Work or Production drawings - Drawings of this type are the most commonly used since all information necessary to completely describe the size and shape of the part is given. Also notes and information concerning procedures and finish are given. Figure 2 shows an example of a typical work drawing.



3. Pictorial drawings - Frequently it is necessary to show the view of an object as one would see it in a photograph. A pictorial drawing is a three dimensional drawing that enables a non-technical person to visualize an object more easily. Pictorial drawings are also used as assembly drawings. Figure 3 is an example of the use of pictorial drawings.



4. Assembled drawings - In the assembly of multiple parts, it is necessary to show how the assembly is made. Frequently, the location of individual parts with respect to each other is important. In either situation the assembly drawing is used. Figure 4 shows the assembly of a circle cutter.



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Drawing Reproductions

Considerable time and investment go into the planning and designing of an original drawing. Therefore, it is vital that the original be stored and filed properly to avoid loss or damage to it. Also, the need for more than one copy, as required due to the various manufacturing processes, does not make the redrawing of the original economically feasible.

To meet these needs a reproduction is made. The reproduction is called a "print", or as frequently referred to, a "blueprint". The term "blueprint", which is becoming obsolete, originated from the early process of reproduction whereby the print was on blue background and the drawing was white lines. Today most prints are made on white paper with blue or black ink lines. In future lessons the term "print" will be used instead of "blueprint".

The procedure for making a print consists of three main steps: These are as follows:

1. Making the original drawing on a transparent paper called tracing paper.
2. Taking a special treated sensitized paper and exposing the drawing and sensitized paper to light. The light exposes everything except where the lines or notes prevent penetration of the light.
3. Developing the sensitized paper by exposing it to either the liquid or fumes of a developing agent, such as ammonia. This causes the unexposed part to become visible, forming the print.

Prints are usually made on the same size paper as the original, although the paper may be cut to various sizes. Common sizes of prints are:

1. Size A - 8½" x 11"
2. Size B - 11" x 17"
3. Size C - 17" x 22"
4. Size D - 22" x 24"
5. Size E - 34" x 44"

Today in many industries where security and storage are vital, microfilming is used. A microfilm is made of a part and is stored either on a roll of film or an aperture card. This permits it to be stored easily and pulled out when the need arises for making a change or to make prints.

ASSIGNMENT SHEET
ON
DRAWING - THE UNIVERSAL LANGUAGE

II-A-1(AS)

SUBJECT: History And Importance Of Technical Drawing

AIM: The student will be able to explain the importance of technical drawing in our industrialized society.

INTRODUCTORY INFORMATION: Graphic communication or language is a means of communication thousands of years old. The development of graphics has progressed greatly from the days of the Egyptians, some 35,000 years ago, to the present. Today, technical drawing, as it is referred to, is essential to our industrial society. Drawings are made in different ways and are used for many purposes. It may be an architectural plan for a home; a road map; production chart; a design drawing; or a freehand sketch of an idea or part. Regardless of how it is used, graphic communication is an important part in our way of life. In daily life people come in contact with many phases of graphic communication, such as assembling toys and appliances, construction work, the manufacturing business, and even the charts and x-rays which are read by doctors.

REFERENCE: Information Sheet II-A-1(IS) "Drawing - The Universal Graphic Language"

QUESTIONS OR PROBLEMS: The student will study carefully Information Sheet II-A-1(IS) "Drawing - The Universal Graphic Language" and complete the true and false questions and simple recall questions as directed.

ASSIGNMENT SHEET
ON
DRAWING - THE UNIVERSAL GRAPHIC LANGUAGE

NAME_____ DATE_____

DIRECTIONS: Read each of the following statements carefully. Some of the statements are true and some are false. Indicate the answer selected by a small circle around the T or F in the corresponding right-hand column.

EXAMPLE:	1. Drawing is vital to the manufacturing industry.	T
1.	The term "universal graphic language" refers to a way of communicating with the use of pictures.	T
2.	One of the first forms of graphic communication was the Egyptian Hieroglyphics.	T
3.	The design drawing is important to the machinist because it gives all necessary information needed to manufacture the part.	T
4.	By "universal" we mean that the use of drawings is confined to our country.	F
5.	Charts are commonly used to show the amount of production that has been met in comparison with the goal set.	T
6.	Multi-part products are assembled with the aid of assembly drawings.	T
7.	Quality control refers to the amount of products that are manufactured in a given period.	F
8.	Many products began as a sketch of someone's ideas.	T
9.	It is unimportant for machinists to be skilled in the reading of prints.	F
10.	A simple way of illustrating an idea is by the use of pictorial drawings.	T
11.	Tracing paper is a transparent paper used in making original drawings.	T
12.	A pictorial drawing shows three dimensions of an object in a single view.	T
13.	Originally blueprints were made with blue lines on a white paper.	F

14. Work drawings provide all the information necessary to manufacture a part. T

15. Ammonia is used to develop the sensitized paper in making prints. T

16. It is more expensive to make a print than it is to make an original drawing. F

17. Transparent material will permit light to pass through. T

18. Diazo is a process of making a print. T

19. The machinist uses the original drawing when machining a part. F

20. The ability to sketch is not important to the machinist. F

SIMPLE RECALL QUESTIONS

II-A-1(AS)
Key

DIRECTIONS: Read each statement carefully. Select a word or words which will complete the statement correctly. Place your answer in the blank space to the right of each statement.

EXAMPLE: 1.	A form of communication portraying animal characters is known as the ____.	Egyptian Hieroglyphics
1.	A design drawing gives the true size and ____ of an object.	shape
2.	____ plans are used in the design and construction of homes and commercial buildings.	architectural
3.	In the ____ department the finished product is checked against the drawing to ascertain all specifications have been met.	quality control
4.	The machinist uses the ____ drawing in the machining of a part.	design/work
5.	The planning and selection of tools for a job is the responsibility of the ____ department.	tooling
6.	A reproduction of an original drawing is called a ____.	print/blueprint
7.	The need for storing a large number of drawings in a small space has brought about the use of the ____.	microfilming
8.	To make a print from an original requires a special ____ paper.	sensitized
9.	To assist non-technical or lay persons in visualizing an object, the ____ drawing is used.	pictorial
10.	A preliminary drawing that is drawn freehand is called a ____.	sketch

MATCHING TEST
ON
DRAWING - THE UNIVERSAL GRAPHIC LANGUAGE

II-A-1(T)
Key

NAME_____ DATE_____

DIRECTIONS: One statement from Column I is closely related to or associated with an item in Column II. Place the letter of the associated term in Column II in the blank space at the left of the number in Column I.

EXAMPLE: B 1. Completion of the temple of Amon

A. 30 B.C.
B. 980 B.C.
C. 1876 A.D.

Column I		Column II
G	1. Communication portraying animals	A. Assembly drawing
L	2. Gives production data	B. Quality control
I	3. Three dimensional view of an object	C. Microfilm
R	4. Material print is produced upon	D. Tracing paper
A	5. Production illustration	E. Tooling Department
P	6. Regulates and controls production process	F. Print
B	7. Inspects finished product	G. Egyptian Hieroglyphics
D	8. Transparent drawing material	H. Work drawing
N	9. Preliminary drawing	I. Pictorial drawing
C	10. Mounted on aperture cards	J. Materials Department
E	11. Determines tooling and production procedures	K. Universal
F	12. Reproduction of an original	L. Chart
Q	13. Developing agent	M. Engineering Department
H	14. Shows true size and shape of part	N. Sketch
J	15. Studies material requirements and availability	O. Map
		P. Production Department
		Q. Ammonia
		R. Sensitized paper

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

II-B-1(I)

SUBJECT:	Alphabet of Lines
AIM:	The student will be able to properly identify; correctly draw; and interpret use of those conventional lines used in industry to completely describe the size and shape of a part.
TEACHING AIDS:	Transparency, I. Ed. M-VII-T, Fig. 1 and 2 Information sheet: II-B-1(IS) "Alphabet of Lines"
MATERIALS:	Chalkboard Overhead projector and screen
REFERENCES:	Basic Blueprint Reading and Sketching Blueprint Reading For Metalworking Trainees Print Reading For Machine Shop
PREREQUISITE EXPERIENCE OF THE LEARNER:	The student must be enrolled in class and must exhibit a desire to learn. Previous experience in drawing is desirable but not mandatory.

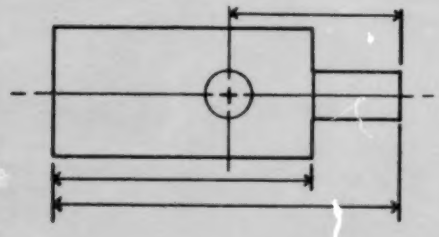
I. PREPARATION (OF THE LEARNER - MOTIVATION)

The line is the basis for all industrial drawings. Have you ever wondered how an object can be so completely detailed that a machinist can accurately visualize the shape of the part and know the exact size? This is accomplished by combining lines of various thickness, length, and type. Each line is made in a specific way and has a specific meaning, so that when combined in a drawing a complete description of the object is provided.

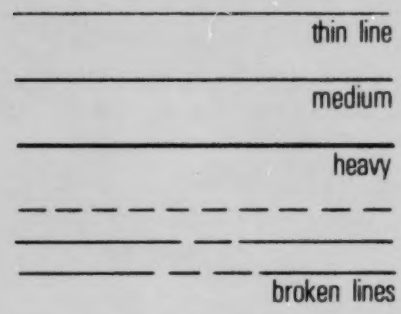
In order for the worker to accurately read and interpret a print, it is essential that a complete understanding of the various types of lines, their use, and the way they are drawn be made.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Conventional Lines Illustrate on board:	1. Provide specific information a. Shape of the part b. Size of the part c. Location or position of part 2. Each line is drawn a certain way a. Weight of line or width (1) Thin (2) Medium (3) Heavy



Illustrate on board:



Note: This will vary some with the size of the drawing

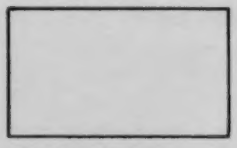
b. Type of line
   (1) Solid
   (2) Broken

3. Each line has a specific meaning
   a. Visible edge
   b. Invisible edge
   c. Center of hole
4. Adopted by American Standards Association to provide standardization of drawings

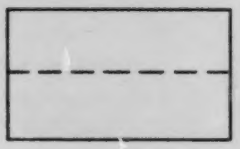
B. Types of Lines
Show: Transparency
Fig. 1 and 2

1. Heavy solid line
2. Indicates all visible surfaces and edges
3. Thickness of line may vary according to size and complexity of part
4. May be referred to as a visible line

1. Object Line

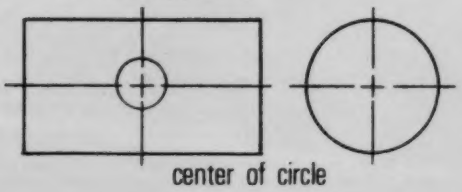


2. Hidden Line

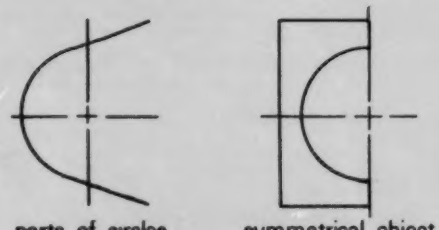


1. Represents invisible edges and surfaces
2. Medium weight line with short dashes
   Note: Size of dashes will vary with size and complexity of drawing
3. Hidden edges will be visible in another view and will be shown as an object line

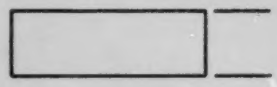
3. Center Line



1. Indicates symmetry or the center of a cylindrical object
2. Indicates the center of holes or parts of a circle such as arcs
3. Light broken line consisting of long (3/4"-1½") and short (1/16" - 1/8") dashes
   Note: Illustrate on board



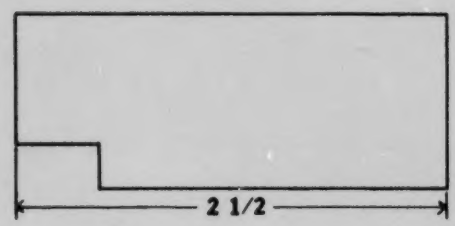
4. Extension Line



1. Medium solid line extending from the edge of the object
   Note: Extension line does not touch line it extends from

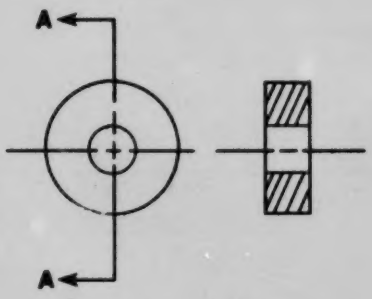
2. Projected for the purpose of indicating lengths and distances for dimensioning
3. Dimensions are normally placed outside the object lines to avoid confusion

5. Dimension Line



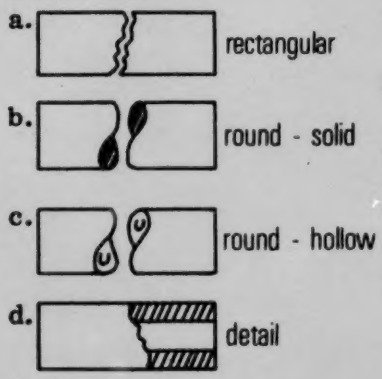
1. Medium solid line usually broken near center
2. Arrowheads at each end extend to extension line
3. Break in line may vary to accommodate dimensions
4. Dimension placed in break indicates distance between extension lines

6. Cutting Plane Line



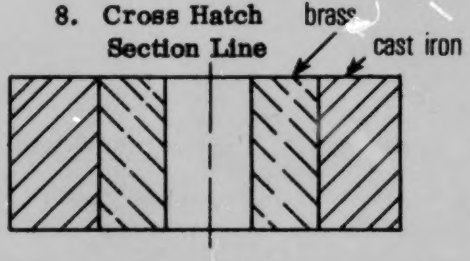
1. Heavy broken line consisting of long dash (3/4" - 1½") and two short dashes (1/16" - 1/8")
2. Line represents the edge of the cutting plane
3. Arrows at end of cutting plane show the direction in which the view is observed
4. A letter is usually placed near each arrowhead to identify the section
5. Cutting plane lines take precedence over a center line

7. Break Line



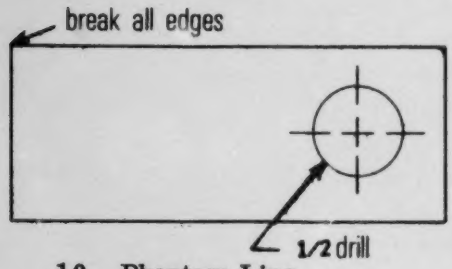
1. Heavy solid line normally freehanded
2. Indicates a part that has been removed from the print
3. Eliminates the use of a large print
   Saves space
4. Does not alter true size or shape of original part
5. Referred to as a conventional break
6. Used also to show internal shape
7. May be long or short break

8. Cross Hatch Section Line



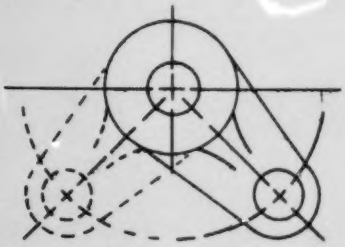
1. Medium lines, equally spaced, usually drawn at 30°, 45°, 60°, across the visible edges of an imaginable cut surface
2. Used to indicate material part is made from
3. Cast iron symbol is generally used to indicate cut surface
4. Illustrate assembled parts

9. Leader Line



1. Solid light line with an arrowhead at one end
2. May be drawn straight with a short intersecting line drawn at an angle
3. Drawn as a curved line
4. Runs from a notation to the point to which the notations refer

10. Phantom Line



1. Very light line with alternating long dash and two short dashes
2. Indicates an object not related to the part and showing:
   a. How part is held
   b. Special tool positioning
   c. Alternate positions
3. Indicates position of an absent part in relation to the view that is drawn

III. APPLICATION: (DRILL, ILLUSTRATIONS ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION).

1. Have students sketch each line, identify it, and name its function or use.
2. Have students discuss the various lines as to the way they are made, the importance of different lines, and the method of drawing the line.
3. Assign students the problems in assignment book on the alphabet of lines.

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED).

Simple Recall

1. The basic line conventions used in reading a print are called the alphabet of lines.
2. Conventional lines are drawn a specific thickness and type.
3. Line weights are classified as thin, medium, and heavy.
4. The object line indicates all visible edges and surfaces.
5. Invisible edge are represented by a/an hidden line.
6. Centers of holes, arcs, or cylindrical parts are designated by the center line.
7. Section lines are used to indicate the material from which the part is made.

8. The leader line runs from a notation to the point to which the notation refers.

9. Break lines are used to save space on the blueprint or to show the internal shape of a part.

10. In showing the alternate position of a part, the phantom line is used.

Matching

Column I		Column II
D	1. ———	A. Extension Line
I	2. ↑— — —↑	B. Break Line
F	3. ← 1/2 drill	C. Section Line
B	4. ~~~	D. Object Line
J	5. ——— — ———	E. Hidden Line
G	6. ——— — — ———	F. Leader Line
H	7. ←——— ———→	G. Phantom Line
C	8. ▨	H. Dimension Line
E	9. — — — — — —	I. Cutting Plane Line
A	10. ▭	J. Center Line

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT).

The basic conventional lines, known as "The Alphabet of Lines", that are used in drawing are the object line, hidden line, center line, dimension line, extension line, phantom line, section line, cutting plane line, break line, and leader line. Each of these lines is made a specific way and has a specific meaning in accurately describing the size and shape of a part. It is essential that the machinist be able to understand the use and meaning of these lines in order to correctly read a print.

SUGGESTED READING FOR THE STUDENT:

"Principles of Multi-View Drawings"

The Next Lesson Is: I-B-2(IS) "Multi-View Drawings"

INFORMATION SHEET
ON
PRINT READING

II-B-1(IS)

SUBJECT: The Alphabet of Lines

INTRODUCTORY INFORMATION:

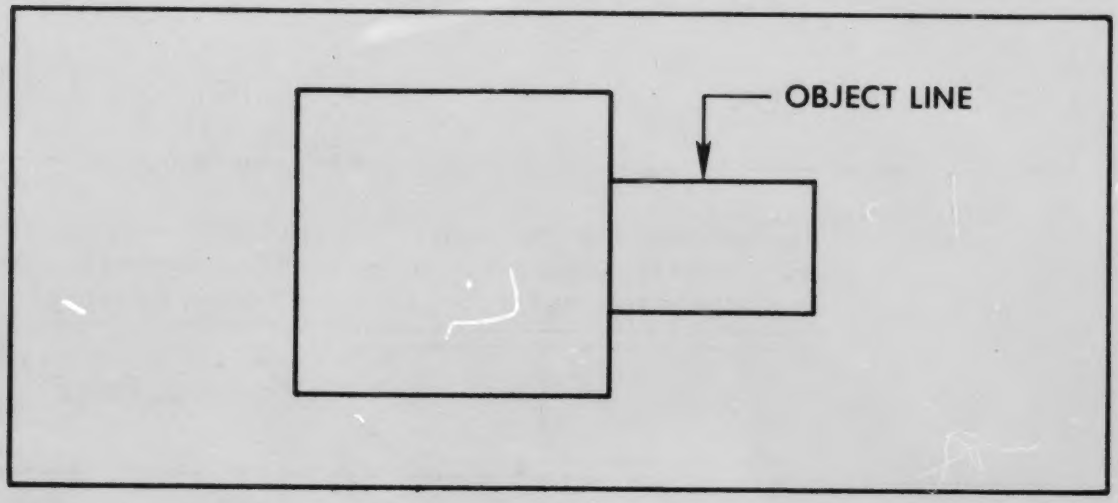
The line is the basis for all industrial drawings. By combining lines of different thickness or weight, length, and type, it is possible to accurately and graphically describe any object in such detail that a person skilled in the art of print reading can accurately visualize the shape of the part. Each line on a technical drawing has a definite meaning and is drawn in a certain way.

The American Standards Association has adopted these line conventions which are commonly referred to as the "Alphabet of Lines", and has recommended certain drafting techniques and standards for lines. The most commonly used lines from this alphabet include: (1) object lines, (2) hidden lines, (3) center lines, (4) dimension lines, (5) extension lines, (6) section lines, (7) cutting plane lines, (8) break lines, (9) leader lines, and (10) phantom lines.

A brief description of each line, with an example of each type, is given in the following information. The weights and sizes of the lines are relative because they depend on the size and complexity of the part drawn.

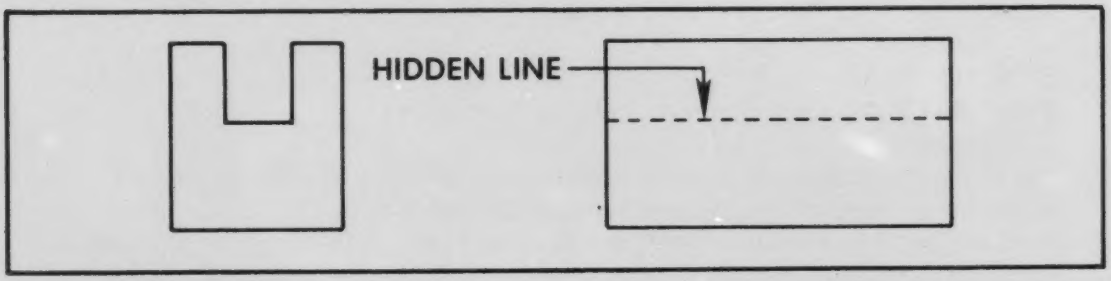
GENERAL INFORMATION

1. Object Line
   A heavy solid line that is used to show or indicate all visible edges or surfaces of an object or any part of the object that is visible from any point of observation.



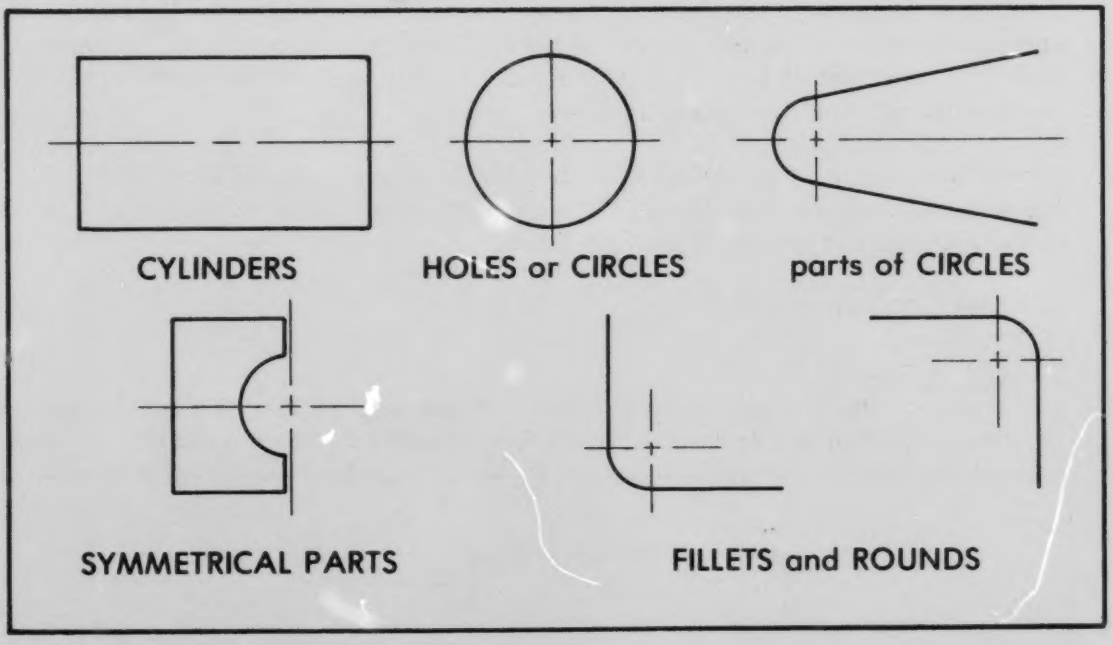
2. Hidden Line

Medium weight line with short dashes. The size of the dash is approximately 1/8", but will vary with the size of the drawing. The hidden line represents those edges or surfaces that are invisible at point of observation.



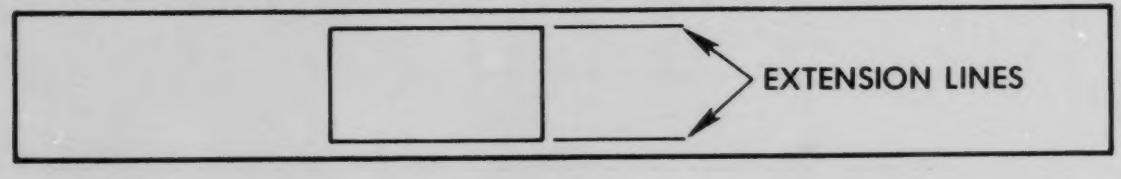
3. Center Line

Light broken line consisting of long (3/4"-1½") and short (1/16"-1/8") dashes. This will vary with size of drawing. It is used to locate centers of holes, parts of circles, such as arcs, and to indicate symmetry or the center of a cylinder.



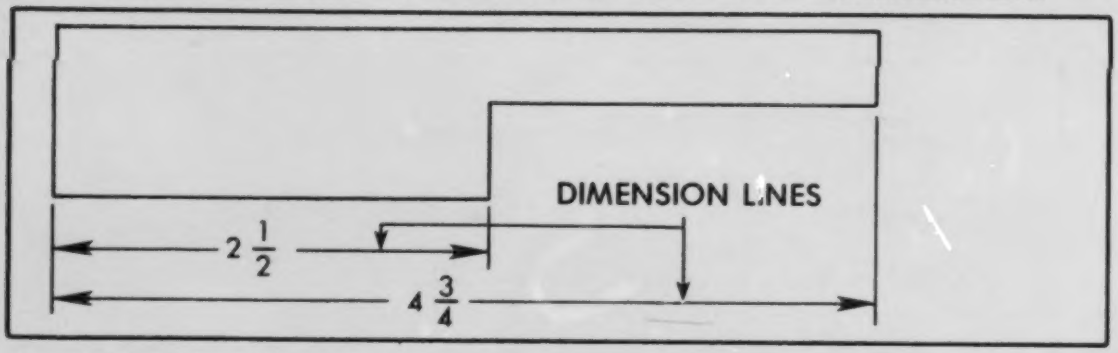
4. Extension Line

Medium solid line extending from the edge of the object for the purpose of indicating distances between two edges for dimensioning. The extension line does not touch the line it extends from and is normally placed outside the object.



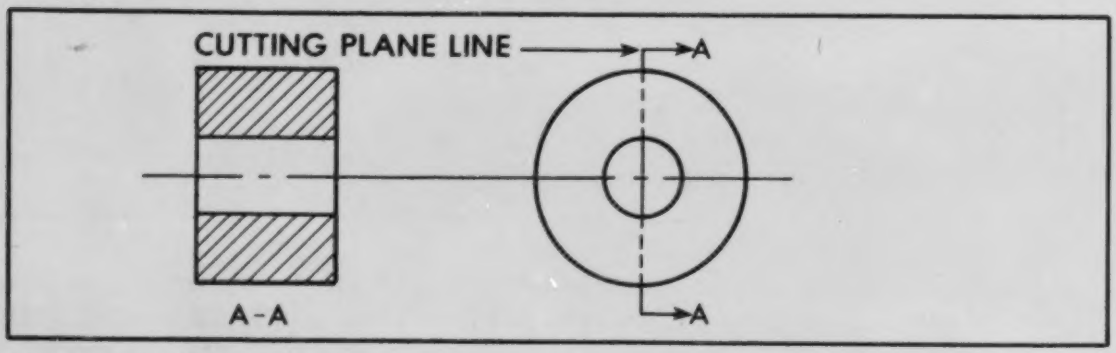
5. Dimension Line

Medium solid line usually broken near the center to allow for the dimension, although the break can vary to accommodate dimension or for clarity. Arrowheads terminate the ends of the dimension line and touch the extension line.



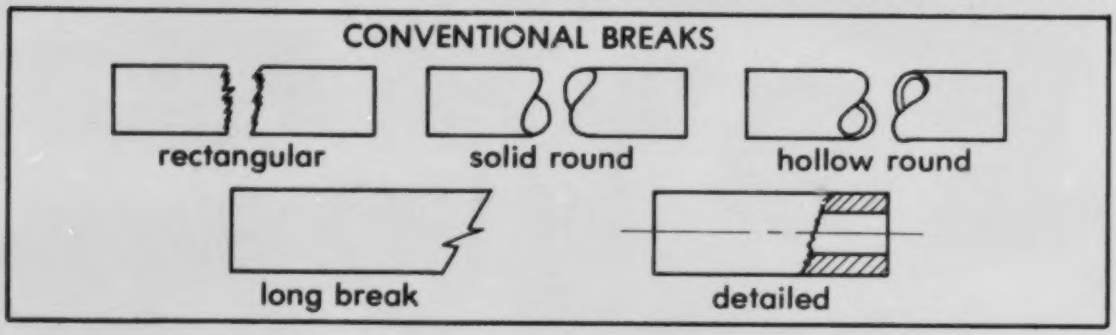
6. Cutting Plane Line

Heavy broken line consisting of long dash (3/4 - 1½") and two short dashes (1/16"-1/8") that represents the edge of a cutting plane for the purpose of showing a sectioned view. At the end of the line arrows are connected and point in the directions that observation of the part is made. In some cases a letter is placed near each arrowhead to identify the section.



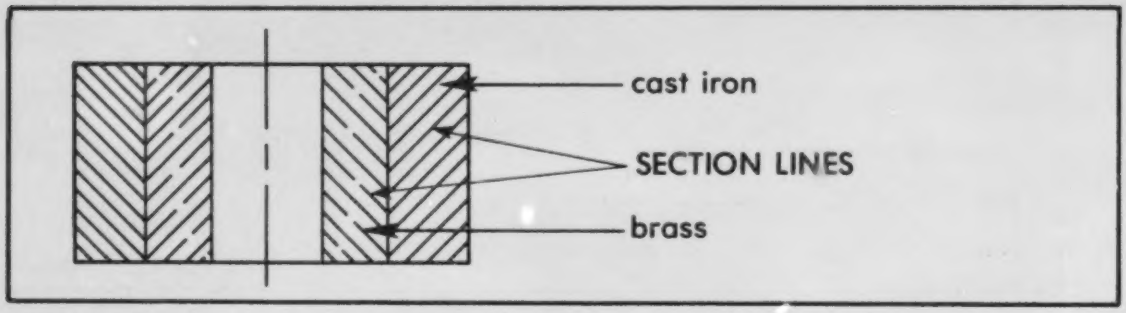
7. Break Line

Heavy solid line normally freehanded to indicate a part that has been removed from the print. It is used to eliminate large drawings to save space or to show the internal shape of a part. It does not alter the true size or shape of the part.



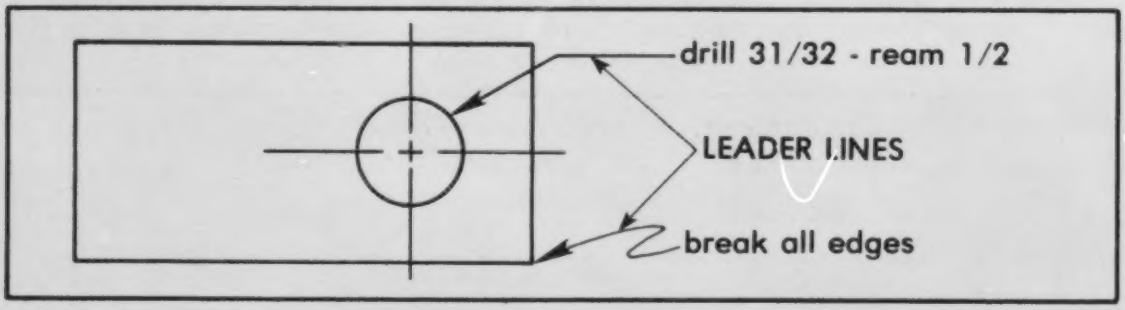
8. Section Line

Medium weight line, equally spaced and usually drawn at 30^{o}, 45^{o}, 60^{o} across the visible edges of an imaginable cut surface. It is used to indicate a cut surface, assembled parts, or the type of material the part is made from. Cast iron is generally used for showing a cut surface.



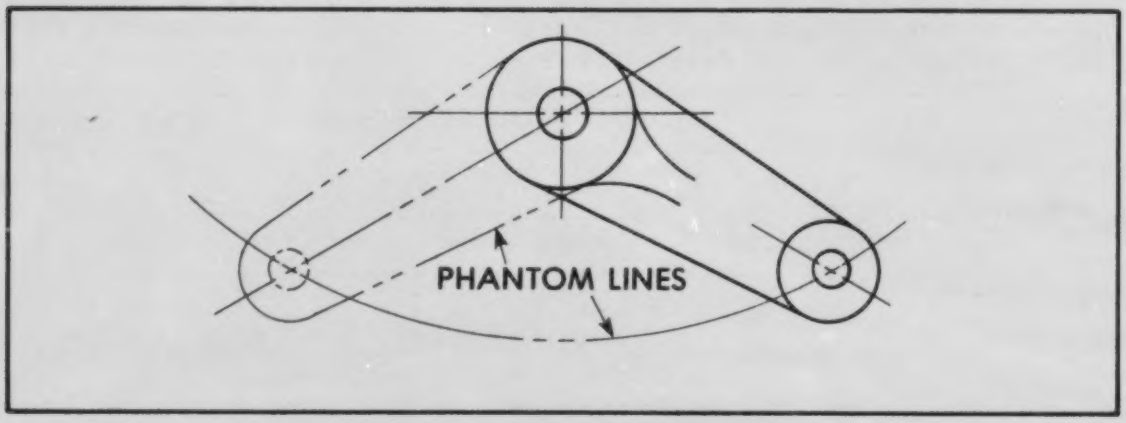
9. Leader Line

Solid line drawn as an angled or curved line with an arrowhead at one end. The leader line is used to refer a note to a certain part of the drawing.



10. Phantom Line

Very light line consisting of alternating long dash and two short dashes (similar to cutting plane line) for the purpose of indicating position of absent part in relation to the view that is drawn; for showing alternate position; special tool positioning or how part is held.



ASSIGNMENT SHEET
ON
ALPHABET OF LINES

II-B-1(AS)

SUBJECT: Conventional Lines Used In Drawing

AIM: The student will properly identify, correctly draw, and interpret the use of those conventional lines used in drawing and print reading.

INTRODUCTORY INFORMATION: Conventional lines called "the alphabet of lines" are the basis for all drawings, regardless if orthographic or pictorial; industrial or architectural; mechanically drawn or sketched. Each line is made a certain weight, size, and either as a solid line, broken line, or a combination of both. The way the line is drawn gives meaning to the line in the interpretation of the drawing. To be able to accurately read a print requires the ability to interpret the meaning of each line. Upon completion of this assignment sheet the student will be able to identify, interpret the meaning, and correctly draw those conventional lines used in drawing.

REFERENCE: Information Sheet II-B-1(IS) "Alphabet Of Lines"

QUESTIONS OR PROBLEMS: In Assignment Sheet II-B-1(AS) the student will identify the given line by sketching each line correctly and showing an example of use for each as illustrated in the given example.

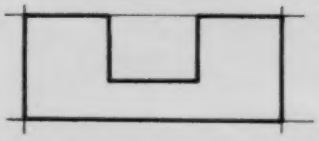
ASSIGNMENT SHEET
ON
ALPHABET OF LINES

II-B-1(AS)
Key

NAME_____ DATE_____

DIRECTIONS: Sketch each of the following lines correctly. Show example of use of each.

EXAMPLE: Construction Line: _____



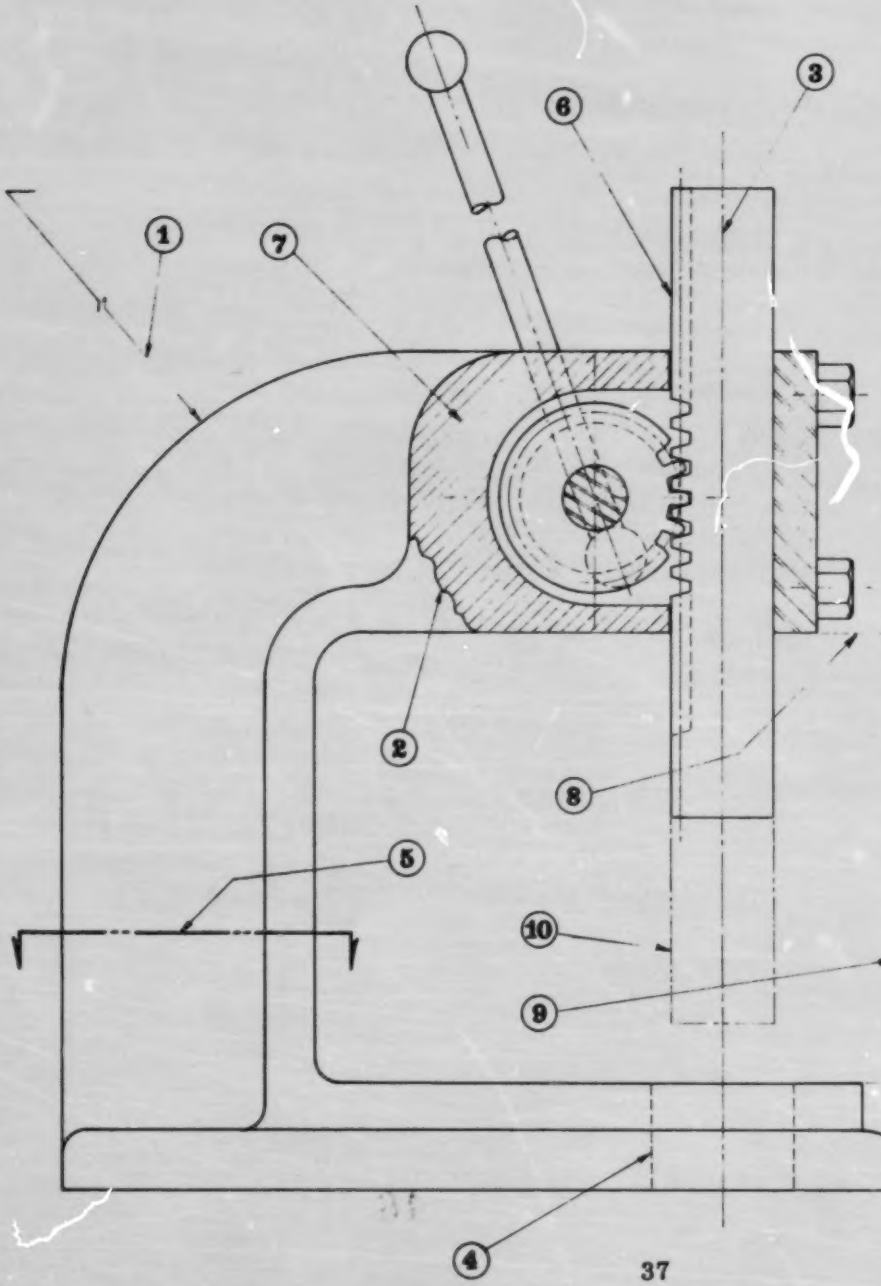
1. Object Line: _____
2. Hidden Line: - - - - - - - - - - - - - - - - - -
3. Phantom Line: _____ - - _____
4. Cutting Plane Line: _____ — — _____
5. Section Line: _____
6. Long Break Line:
7. Short Break Line:
8. Extension Line:
9. Dimension Line:
10. Center Line: _____ — — _____
11. Leader Line: _____

PICTORIAL RECALL TEST
ON
ALPHABET OF LINES

II-B-1(T)
Key
p. 1 of 2

NAME_____ DATE_____

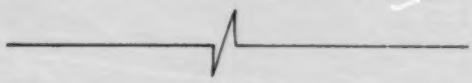
DIRECTIONS: Identify each of the lines indicated in the illustration below. Write the correct answer in the space provided.



1. Leader line
2. Short break
3. Center line
4. Hidden line
5. Cutting plane line
6. Object line
7. Section line
8. Extension line
9. Dimension line
10. Phantom line

MATCHING TEST

DIRECTIONS: One statement from Column I is closely related to or associated with an item in Column II. Place the capital letter of the associated term in Column II in the blank space at the left of the number in Column I.

Column I	Column II
K 1. Indicates symmetry	A. Phantom Line
J 2. Represents invisible edges	B. Section Line
F 3. Gives distances between two edges	C. Broken
H 4. Imaginary plane for the purpose of showing a sectioned view	D. Extension Line
I 5. Used to shorten large drawing	E. Cast Iron
B 6. Indicates type of material or shows assembled parts	F. Dimension Line
M 7. Shows the main visible shape of the part	G. Alphabet of Lines
D 8. Gives reference from which a dimension is given	H. Cutting Plane Line
A 9. Used to show alternate position	I. Break Line
P 10. Standardized and adopted the lines used in print reading	J. Hidden Line
C 11. Lines may be solid or ____	K. Center Line
G 12. Common name for the lines	L. Leader Line
E 13. Common cross hatch line used to show a sectioned surface	M. Object Line
L 14. Refers note to a certain part of the drawing	N. A.M.A.
R 15. 	O. Thick Line
	P. American Standards Association
	Q. Thin Line
	R. Long Break Line

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

II-B-2(I)

SUBJECT:	Multi-View Drawing
AIM:	The student will be able to understand the principles of multi-view drawings; the theory of projection; relationship of views; and be able to visualize drawings that are common to the machinist.
TEACHING AIDS:	Transparencies, I. Ed. M-VII-T, Figures 3-10 Information Sheet: II-B-2(IS) "Principles of Multi-View Drawings"
MATERIALS:	Chalkboard, overhead projector and screen
REFERENCES:	Basic Blueprint Reading And Sketching Blueprint Reading For Metalworking Trainees Print Reading For Machine Shop Technical Drawing
PREREQUISITE EXPERIENCE OF THE LEARNER:	The student must be enrolled in class and must exhibit a desire to learn. The student must have also completed the previous lesson II-B-1(I) "Alphabet of Lines".

I. PREPARATION (OF THE LEARNER - MOTIVATION)

For the machinist to manufacture parts that are designed by the engineer or designer and drawn up by the draftsman requires skill in the reading and interpretation of the design, which is called a drawing or print. While the draftsman represents the part by means of a drawing, the machinist must produce the part based on information given on the print. To do this effectively, the machinist must first be able to visualize the part that is to be produced. This sounds like a complicated task, and it is until a few basic principles of orthographic projection are understood. To read a print requires an understanding of the different views of the object, how they are projected, principal dimensions of an object, and the relationship of views. The understanding of these basic principles will make the reading and interpretation of a drawing much more simple, thereby reducing production mistakes and production time.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Technical Drawing	1. A universal language 2. A graphic language (art form) 3. A means of communication 4. A graphic representation of a real object 5. A combination of lines and symbols which can be viewed and interpreted into meaningful information

B. Multi-View Drawing

1. Most used form of technical drawing
2. Also referred to as orthographic projection
3. Often called work drawing

C. Advantages

1. Furnishes complete size and shape description
2. Provides necessary dimensions and notes for the construction and/or manufacturer

D. Theory of Multi-View Drawing

1. Projection of an object upon an imaginary plane between object and viewer
2. Imaginary plane, "plane of projection", is vertical and square with line of sight (lines of projection)
3. Line of sight is eye level
   a. Viewer is infinite distance from object
   b. No depth perception of object is viewed
   c. Only surfaces and lines visible to viewer are projected
4. Lines of projection are brought forward (toward viewer) piercing planes
5. Pierce points produce flat image of object view

Show: Transparency Figure 3

E. Normal Views of Projection

1. Six regular views as the sides of a block
   a. Front - as selected by the viewer
   b. Right side - as viewed from the right side
   c. Left side - as viewed from the left side
   d. Top - as viewed looking down
   e. Bottom - as viewed looking up
   f. Back - as viewed looking at back
2. Normal planes of projection would be:
   a. As a glass box enclosing the box
   b. Sides of the glass box parallel (normal) with sides of block

Show: Transparency Figure 4

F. Relationship of Views

1. Pretend planes of projection form glass box
   a. Box is hinged on frontal plane
   b. Top, bottom, left side, and right side are hinged to frontal plane
   c. Back is hinged to left side
2. Open box (projections) up
   a. Open ninety (90) degrees
   b. Each will be flat and flush with frontal plane (front view)
3. All views are in proper relation as presented in multi-view drawings

Show: Transparency Figure 5

Note: Front, top, and bottom are aligned vertically; front, right side, left side, and back are aligned horizontally

G. Principal Dimensions

Show: Transparency Figure 6

1. Principal dimensions of an object are:
   a. Width - measured from end to end
   b. Height - measured from top to bottom
   c. Depth - measured from front to back
2. Terms are fixed for dimensions regardless of shape of object
   Note: Terms such as "length" or "thickness" would not be applicable in most cases
   Note: Point out some problems in term use
3. Two principal dimensions are seen in each view
   a. Front and back - height and width
   b. Top and bottom - width and depth
   c. Right and left side - height and depth
4. Four views have one common principal dimension
   a. Height - front, back, left and right sides
   b. Width - front, back, top, and bottom
   c. Depth - top, bottom, left and right sides

H. Principal Planes of Projection

Show: Transparencies Figures 7, 8

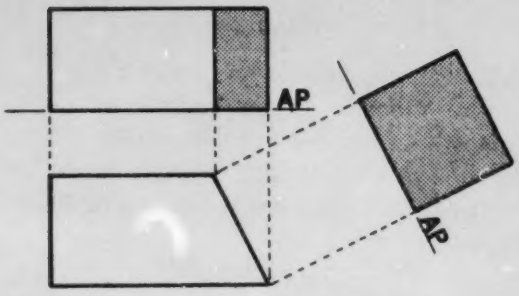
1. Third angle projection is standard in U.S.
2. Third angle includes:
   a. Front - frontal plane, shows most detail
   b. Top - horizontal plane - shows plan and depth
   c. Right side (end) - shows profile
   Note: One or more views may be used to show details difficult to see otherwise. The rule is: "whatever it takes to convey the information necessary to construct/manufacture the part". This includes auxiliary and sectional views

I. Special planes of Projection

Show: Transparency Figure 9

1. A projection required to show highly detailed and complex parts that cannot be shown clearly in a principal view
   Example: Inclined or sloping surface or the interior of a complicated part
2. Types of special planes are:
   a. Auxiliary - projection of a surface not parallel with the normal planes of projection

Example: Illustrate on chalkboard

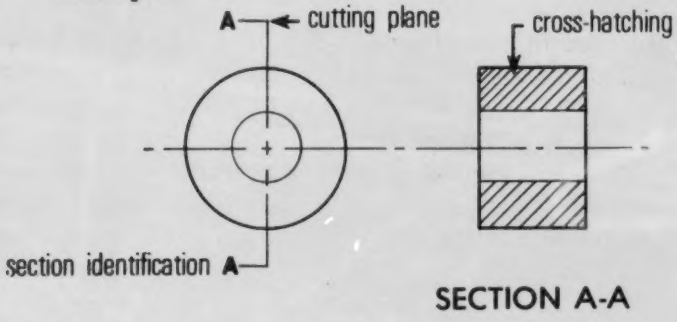


(1) Auxiliary "plane of projection" is parallel to edge view of inclined surface
Note: Projectors are perpendicular to edge view
(2) Produces true image of inclined surface (show example on board)

Show: Transparency Figure 10

b. Sectional - intended to show interior of an object
(1) Part is cut by an imaginary plane referred as a "cutting plane"
(2) Section is removed showing interior part
(3) Material cut is shown by cross-hatching (section lines)
(4) Direction that section is viewed is indicated by arrows
(5) Section is identified by letters

Example:



III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

1. Have students review the six regular views of a block.
2. Have students sketch the six regular views in their relative position, labeling each view and giving dimension found in that view.
3. Have students sketch the six views of an object, showing all visible and invisible edges.
4. Assign students assignment sheet completing missing lines.
5. Assign students assignment sheet completing missing views.

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENTS' COMPREHENSION OF MATERIALS PRESENTED.)

Simple Recall

1. Technical drawing is a universal graphic language used to show the true size and shape of an object.
2. The imaginary plane that points of an object are projected to is the plane of projection.
3. In a projection there are 6 regular (normal) views.
4. The three principal planes of projection are the frontal, profile, and horizontal.
5. The principal dimensions of an object are:
   1. width
   2. depth
   3. height
6. In the front view the principal dimensions seen are width and height.
7. The principal dimension common to the right side view and the top view is depth.
8. Width is a principal dimension common to the front, top, and bottom views.
9. The projection of a surface not parallel with a normal plane of projection is called a/an auxiliary projection.
10. The imaginary plane in a sectional view is referred to as the cutting plane.

Questions For Discussion:

1. What are the advantages of a multi-view drawing?

   Answer:
   1. Furnishes complete size and shape description
   2. Provides dimensions and notes necessary for construction and/or manufacture

2. How is the "glass box" used to illustrate the relationship of views?

   Answer:
   1. Each side of glass box represents a projection plane parallel to each regular view of the object
   2. All planes are hinged to the frontal plane except the back plane
   3. Each plane when opened 90^{o} will be flat and flush with the frontal plane
   4. All views will take their proper position with respect to the front view and each other

3. Certain views contain the same principal dimensions. List the principal dimension and views that contain the dimension.

   Answer:
   1. Width - top, front, bottom, and back
   2. Height - front, right and left sides, and back
   3. Depth - top, right and left sides, and bottom

4. Why are the terms "length" and "thickness" not practical?

   Answer: They apply in only specific cases, rather than most cases

5. Two types of views used to supplement the normal views are:

   Answer: 1. Auxiliary view of inclined surfaces
   2. Sectional view to show internal features

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

The system of drawing most commonly used on industrial prints in the United States is orthographic projection, more commonly referred to as multi-view drawings. This means right angle or perpendicular projection, as all of the principal planes are at a right angle to each other. In this system there are six main views coinciding with the six principal planes of projection. These views are: front, back, top, bottom, right side, and left side.

There are three principal dimensions of an object; namely; width, height, and depth. Each view contains only two of these dimensions, thereby making it necessary to show a minimum of two views in completely describing an object.

A front view or main view is selected on the basis of the view that shows best the essentials, such as contours and shapes. After that, a system of views began. Each view drawn after the front view is on a plane which is at a 90^{o} angle to the preceding view. Two views are usually sufficient for simple objects, while complex objects may require three or more views. The general practice is to use the front, top, and right side views first. Other views may be used where essential.

For many complex parts or objects with inclined or oblique surfaces, either sectional or auxiliary views are developed. These will be covered specifically in another lesson.

SUGGESTED READING FOR THE STUDENT:

II-B-3(IS) "Dimensions and Dimensioning Practices"
II-B-3a(IS) "Abbreviations, Notes, and Symbols"

The Next Lesson Is: II-B-3(I) "Dimensions, Notes, and Symbols"

INFORMATION SHEET
ON
PRINT READING

II-B-2(IS)

SUBJECT Theory of Multi-View Drawings

INTRODUCTORY INFORMATION:

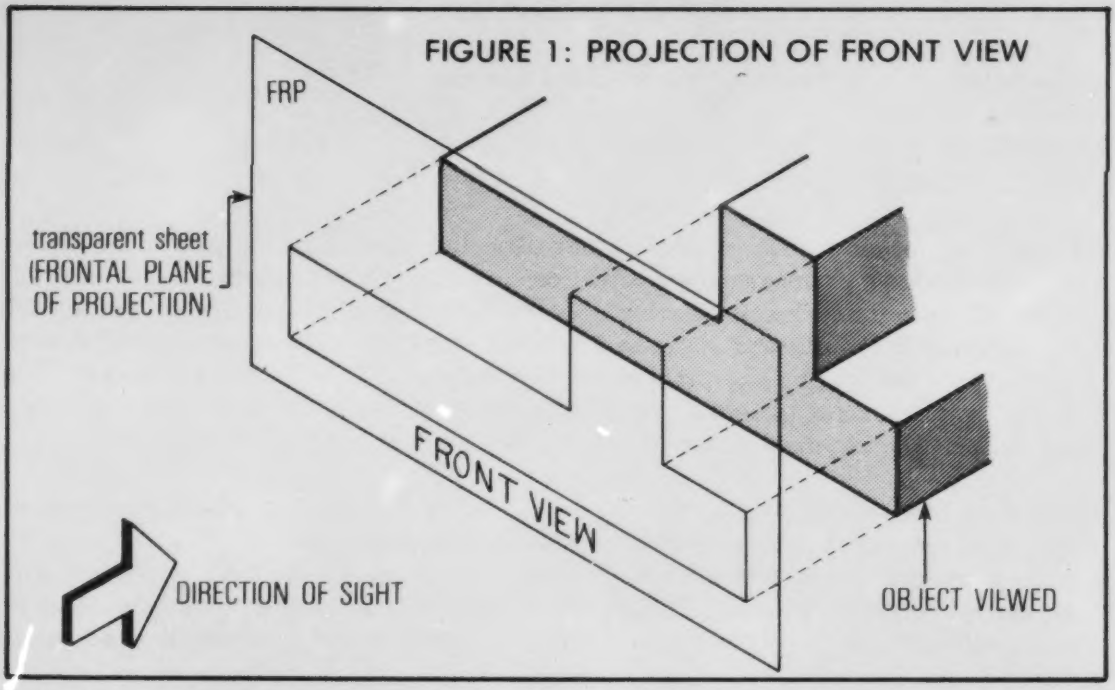
The system of technical or engineering drawing used on most prints in industry is referred to as orthographic projection or multi-view drawing. The machinist often refers to it as a work drawing because all infromation required to produce the part is given in the drawing. The orthographic drawing, unlike the pictorial drawing that shows a picturelike view that is easy to understand but does not present the object in its true shape, presents the object as it actually is, giving all necessary views and information required to completely describe the object.

It is the job of a draftsman to represent the part to be produced by means of a drawing. The machinist must produce the part on the basis of the information contained in the drawing. To do this effectively, the machinist must first be able to visualize the part to be manufactured. The ability to read and interpret a drawing quickly and accurately is important to industry in the terms of time and production, which means money to the company.

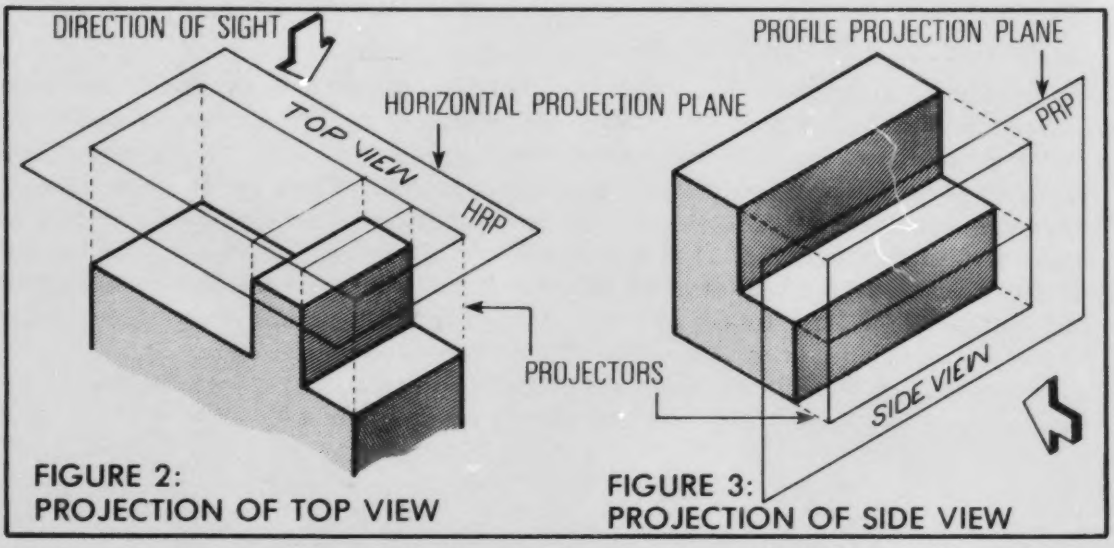
GENERAL INFORMATION

Multi-View Projection (Orthographic)

An orthographic projection is the projection of an object onto an imaginary plane called "the plane of projection". The plane of projection, placed between the viewer and the object, is vertical and square with the line of sight of the viewer. These lines of sight are referred to as lines of projection. The object is theoretically viewed at eye level with the viewer an infinite distance from the object, so that the lines of sight are parallel. Let us assume that the person who makes the drawing places a transparent sheet or glass directly between self and the object, and traces the outline of the object as it appears through the transparent sheet. The outline would portray that view or side of the object in true shape, as seen in Figure 1. The viewer would not be able to detect depth in the object. The projection plane in this case is a frontal plane; therefore, the view is the front view.



To get a more complete representation of the object, let us project two other views in the same manner as in Figures 2 and 3.



In Figure 2, the object is viewed through a horizontal projection plane, which is perpendicular to the frontal plane; thus, the top of the object is viewed. By the same thought, in Figure 3, the object is viewed through the profile plane which is perpendicular to the frontal and horizontal plane. As a result, we have three planes of projections or views that are perpendicular to each other and form a box-like figure as in Figure 4.

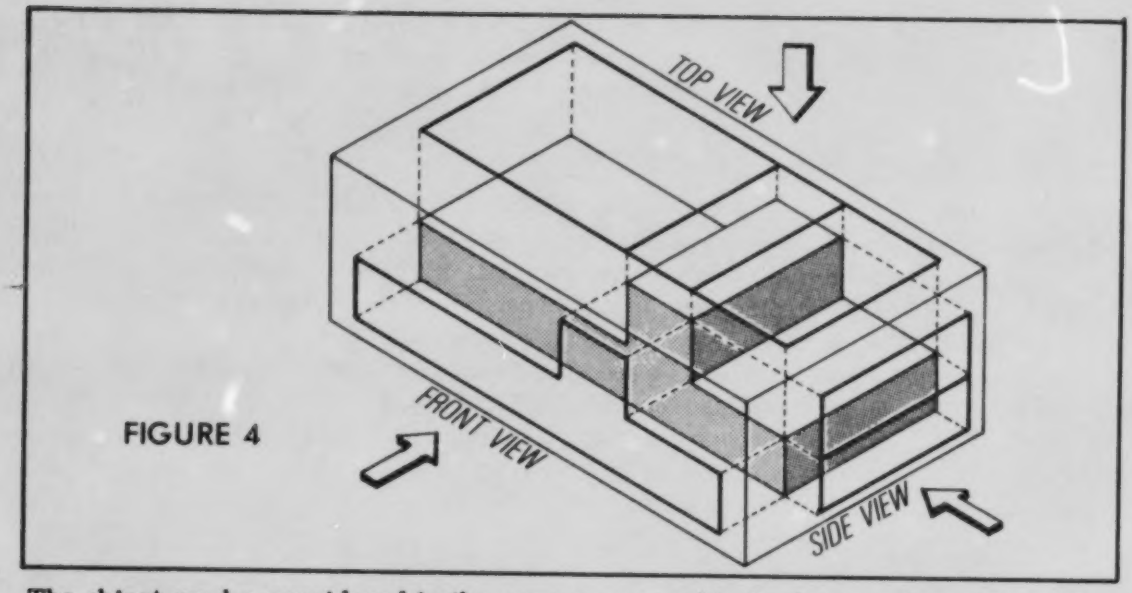


FIGURE 4

The object can be considered in the same way as a block, having six regular sides, thereby containing six normal views of projection. We have already viewed our object from the front, top, and side, and we can continue by observing the bottom, back, and left side in the same manner.

Another way to visualize a multi-view drawing is by enclosing the object with a glass box whose sides are parallel to the sides of the object. The sides of the glass box represent the planes of projection. In observing, we find that the bottom, left side, right side, and top are hinged to the front, with the back hinged to the left side, as in Figure 5. Upon opening the box or unfolding each side of the box 90°, the sides or views take their respective positions with each other. All views take their position directly above, below, or to one side or the other of the front view, with the back view to the left of the left side.

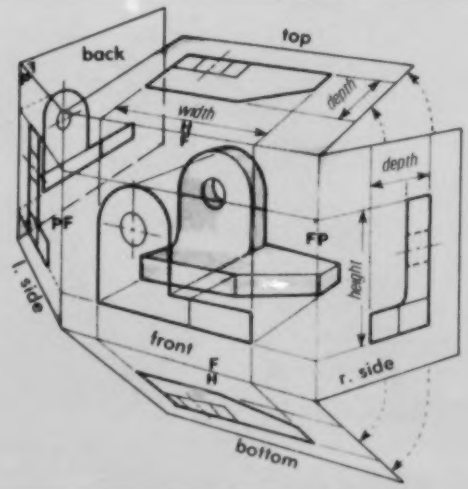


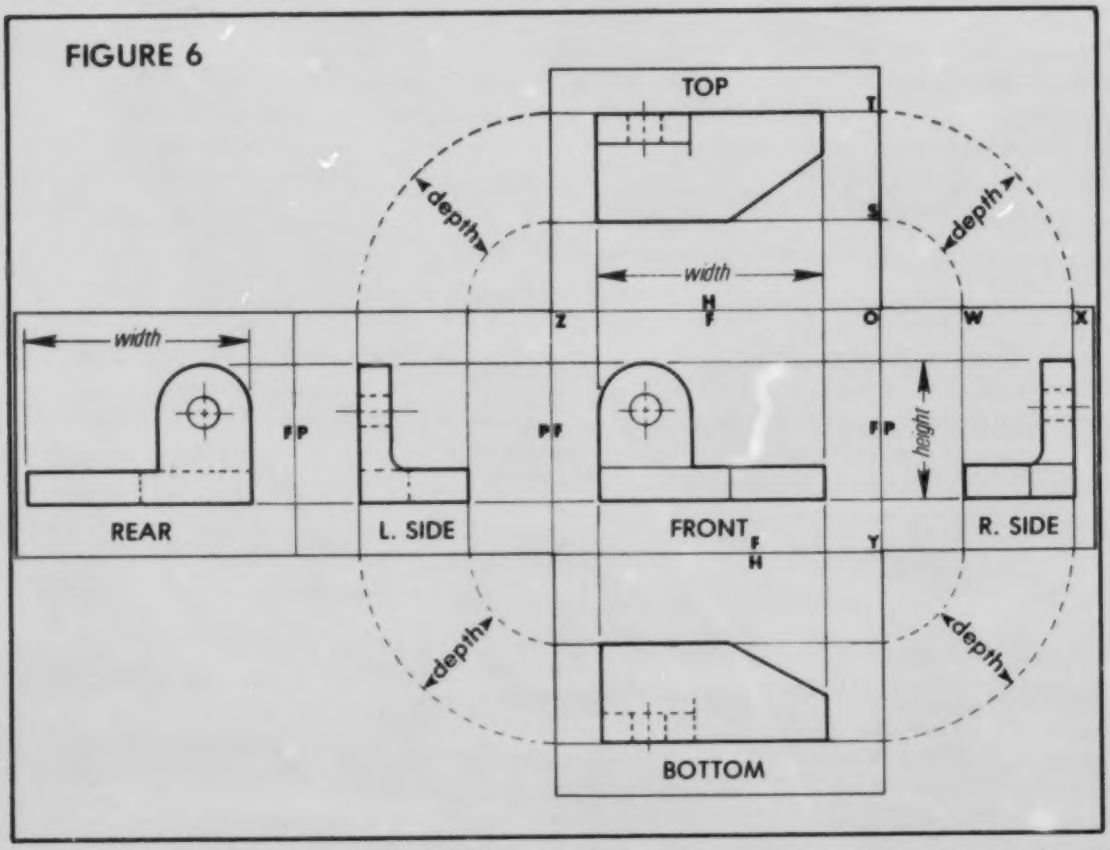
FIGURE 5

As we view an object, we find that it has three principal dimensions; namely: width, height, and depth. These terms are fixed for dimensions regardless of the shape of the object, although sometimes another term would seem more appropriate.

Principal Dimensions of an Object

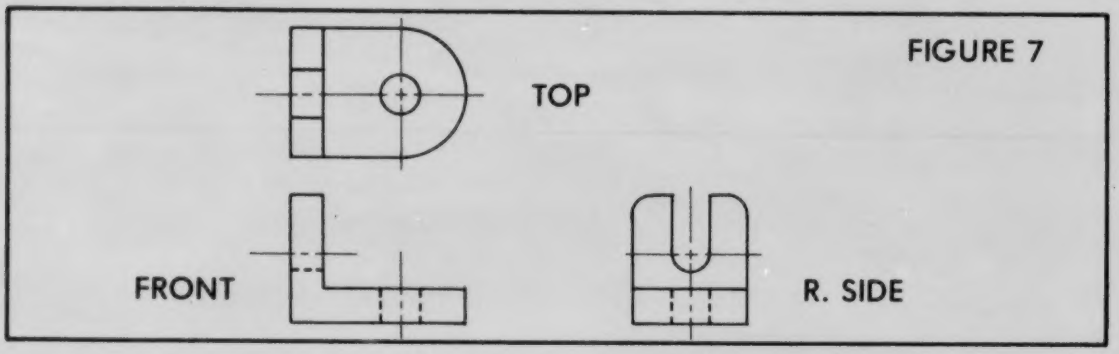
Each view of an object contains only two principal dimensions. For example, in the front view the principal dimensions are height and width. By the same token, the back view also has height and width as the principal dimension. In the side (profile) views, height and depth are the principal dimensions, while depth and width are seen in the top and bottom (horizontal views). In Figure 6, where the planes of projection of the glass box are unfolded so as to see all six views in their relative position, note the principal dimensions contained in each view and those with common dimensions. The front, rear, and side views have height as a principal dimension, while the top, front, rear, and bottom views have width as a principal dimension. The top, bottom, and side views have depth as a principal dimension.

FIGURE 6



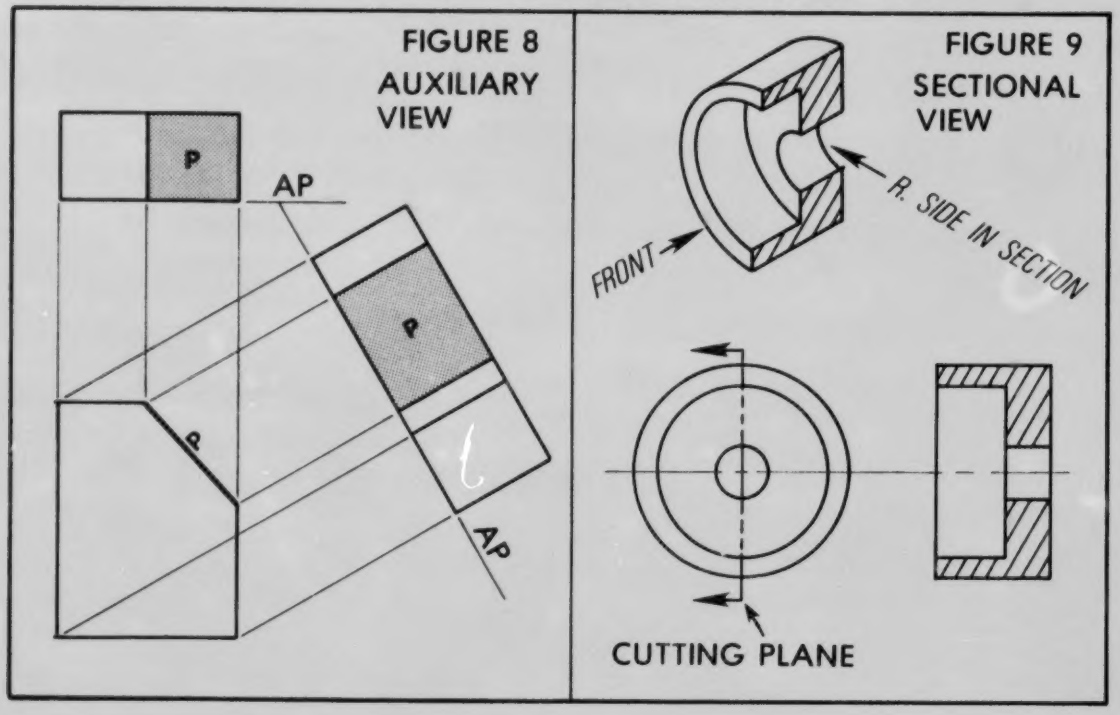
From this it is easy to understand that in order to completely describe an object requires at least two views, except in special cases where a single view and a note can be used. In more complex objects, three and sometimes additional views are required. As a general practice, the front view is selected first, and normally the

top and right side view would be used where necessary, as in Figure 7. Although this is the general practice, it is not absolute that these are the only views used, as in some cases the left side view may be the best selection. The normal rule followed is: "whatever it takes to clearly convey the information necessary to construct or manufacture a part." This includes special views such as the auxiliary and sectional view.



Special Planes of Projections

Where highly detailed or complex parts are shown, views may be used to show inclined surfaces or the interior of complex parts. There are two types of special planes of projection: (1) auxiliary planes for the projection of views that are not parallel with any normal plane or view, (see Figure 8); and (2) sectional cutting planes for describing the interior of complex parts (see Figure 9). Both of these special planes of projection will be covered individually in a later lesson.



ASSIGNMENT SHEET
IN
PRINT READING

II-B-2(AS)

SUBJECT: Multi-View Drawings

AIM: The student will be able to exhibit those skills necessary to correctly read a multi-view drawing by sketching in those missing lines that will make each view of the given object correct.

INTRODUCTORY INFORMATION: In the reading of a multi-view drawing a person must be able to visualize the object in three dimensions. An object consists of various geometric figures that intersect each other. Where they intersect forms an edge that may be a straight line or a curved line. The line may be vertical, horizontal, inclined, or curved. It may be a hidden line in one view and a visible line in another. These assignment sheets are designed to help the student understand the relationship between the views of a given object. In working these assignments, it should be kept in mind the manner in which views of an object may be imagined projected onto the sides of a transparent box. Review Information Sheet II-B-2(IS) "Theory of Multi-View Drawing" before beginning the assignment.

REFERENCES: Information Sheet II-B-2(IS) "Theory of Multi-View Drawing"
Information Sheet II-B-1(IS) "Alphabet of Lines"

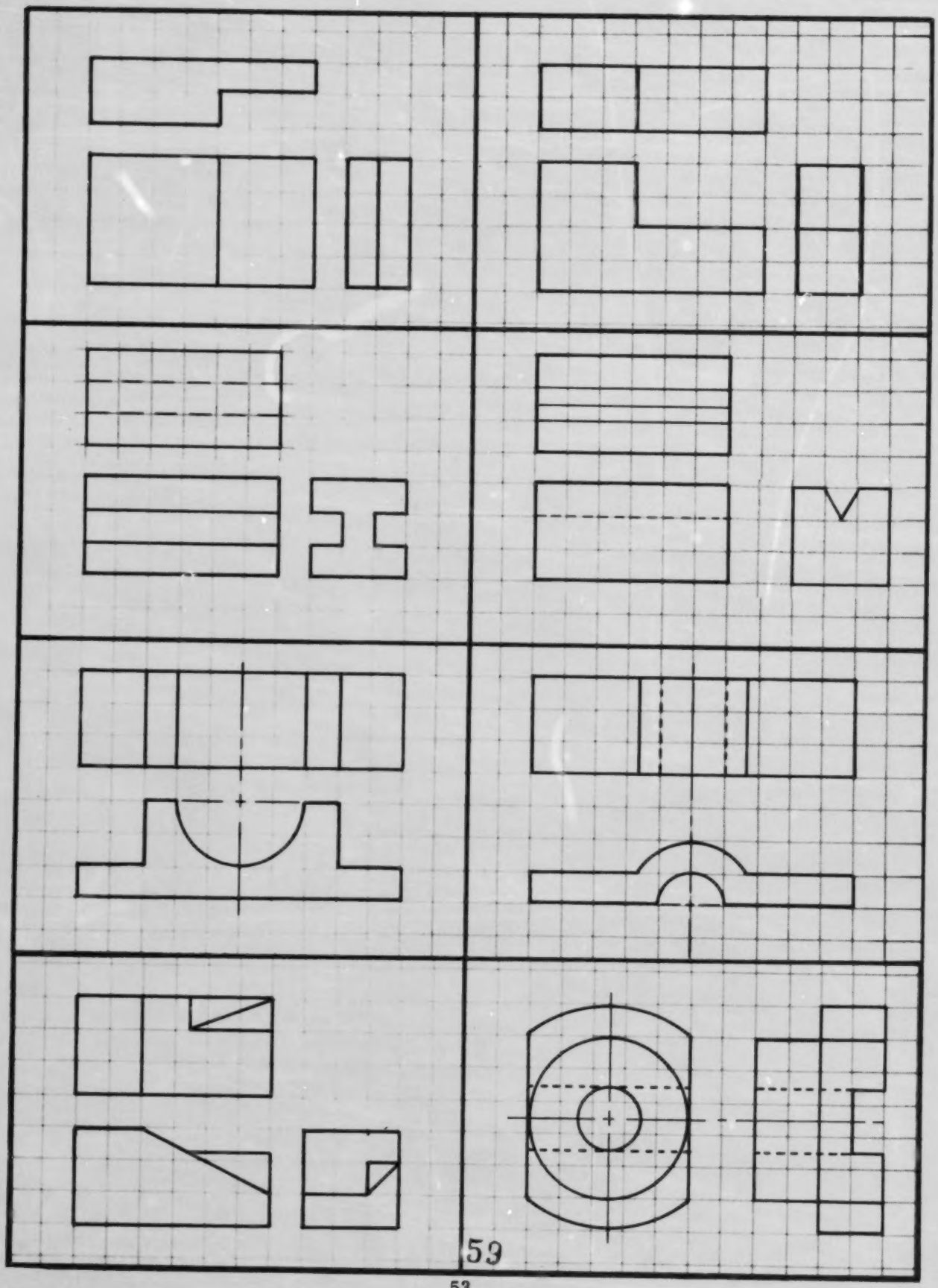
QUESTIONS OR PROBLEMS: In the given problems, study the given views and sketch in those missing lines that would make each view complete and correct. Some problems will have only two views given as that is all that is required to describe the object. The student is to work Assignment Sheet II-B-2 (AS) as instructed by the instructor.

MISSING LINE EXERCISE # 1

II-B-2(AS)

Name:_____

Date:_____

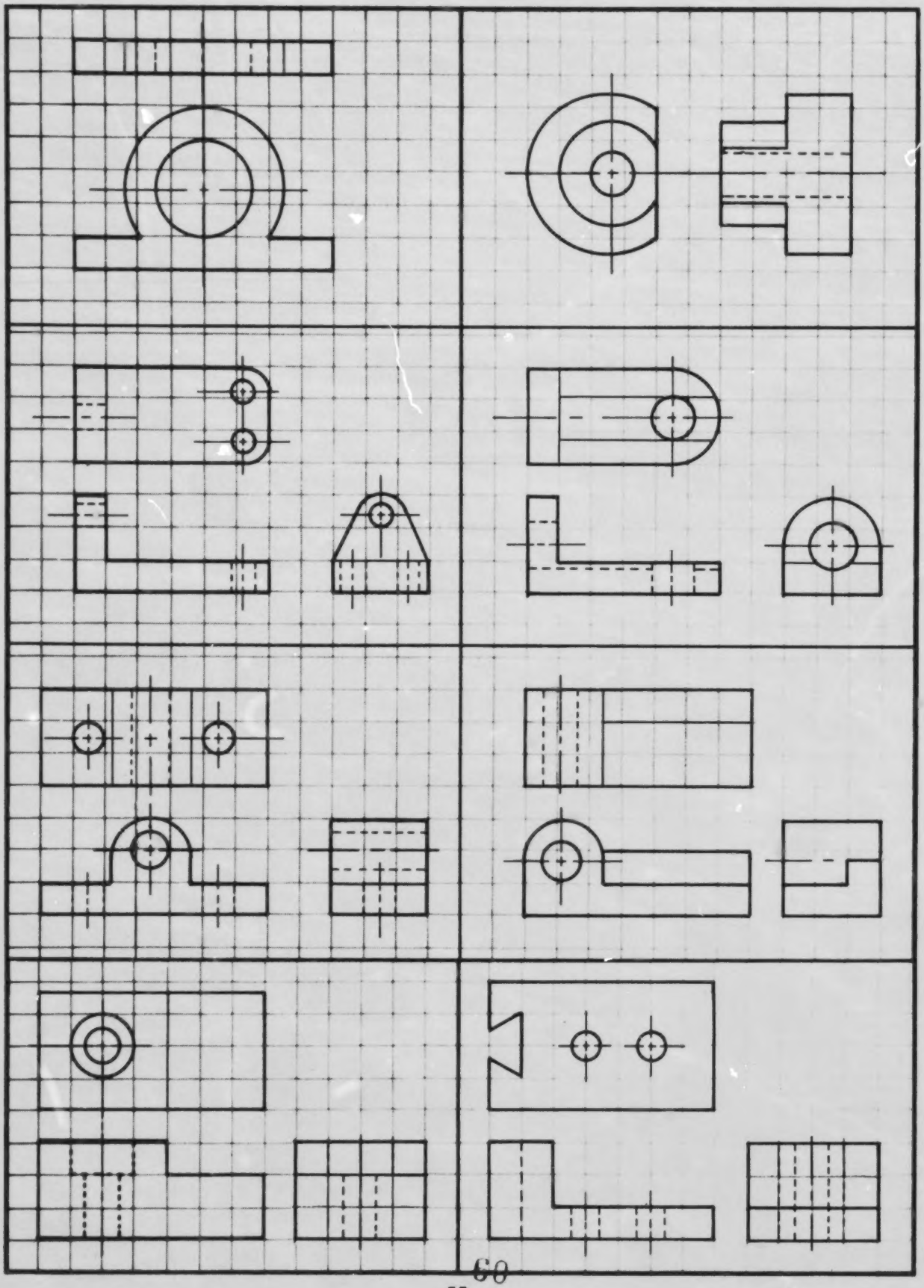


MISSING LINE EXERCISE #2

II-B-2(AS)

Name:_____

Date:_____



ASSIGNMENT SHEET
IN
PRINT READING

II-B-2a(AS)

SUBJECT: Multi-View Drawings

AIM: The student will be able to further develop the skills of reading multi-view drawings by examining the pictorial drawing given and completing the multi-view drawing by adding the necessary lines.

INTRODUCTORY INFORMATION: In Assignment Sheet II-B-2(AS) the student examined each of the given views of an object and sketched in the necessary lines that would make each view complete and correct. In this assignment the student will continue the study of multi-view drawings so as to further those skills required in print reading.

REFERENCES: Information Sheet II-B-1(IS) "Alphabet of Lines"
Information Sheet II-B-2(IS) "Theory of Multi-View Drawing"

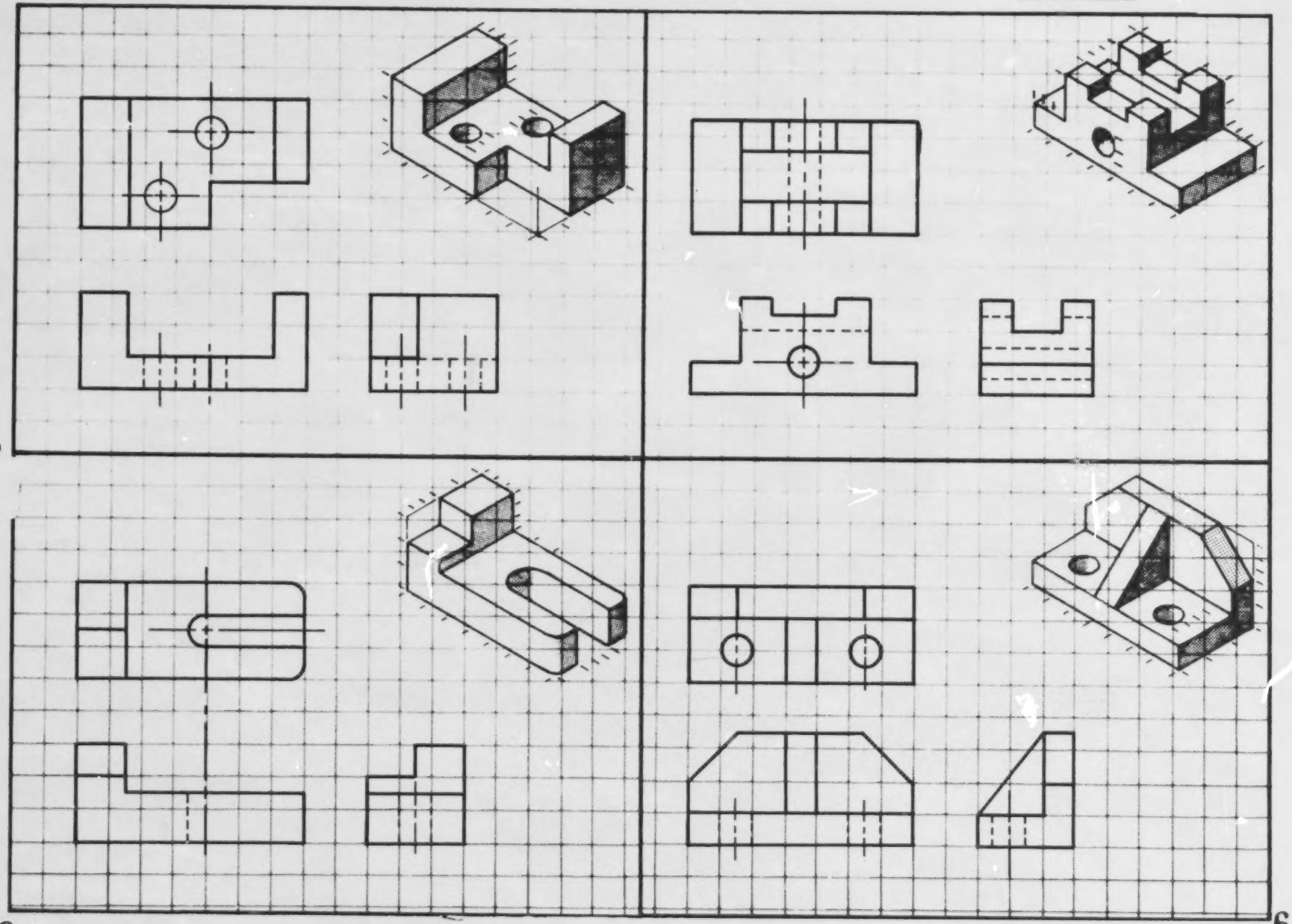
QUESTIONS OR PROBLEMS: The following assignment sheets are provided to give the student further practice in understanding the relationship between views and the objects they represent by completing the drawings. The students will study the pictorial drawing and sketch the three views of the object completely showing all visible, hidden, and center lines.

MULTI-VIEW EXERCISE #1

II-B-2a(AS)

Name:_____

Date:_____

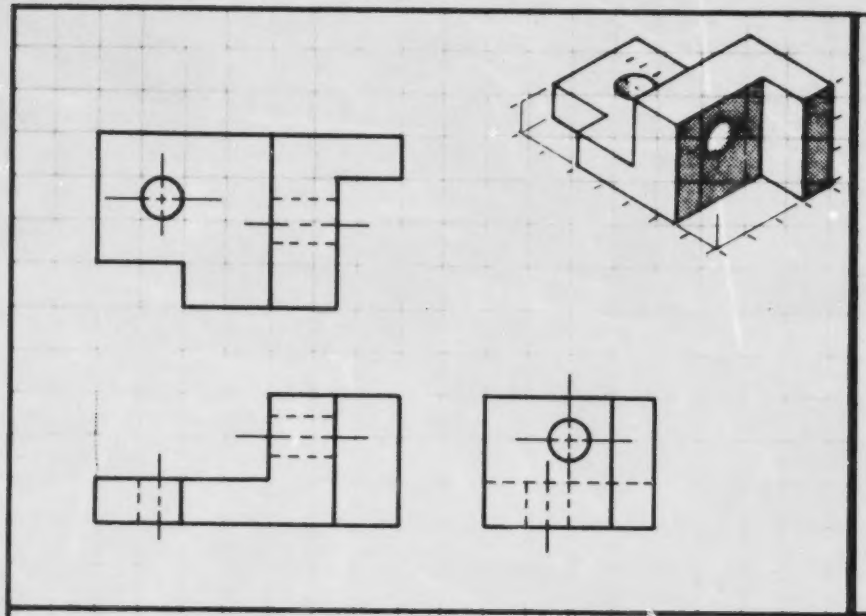


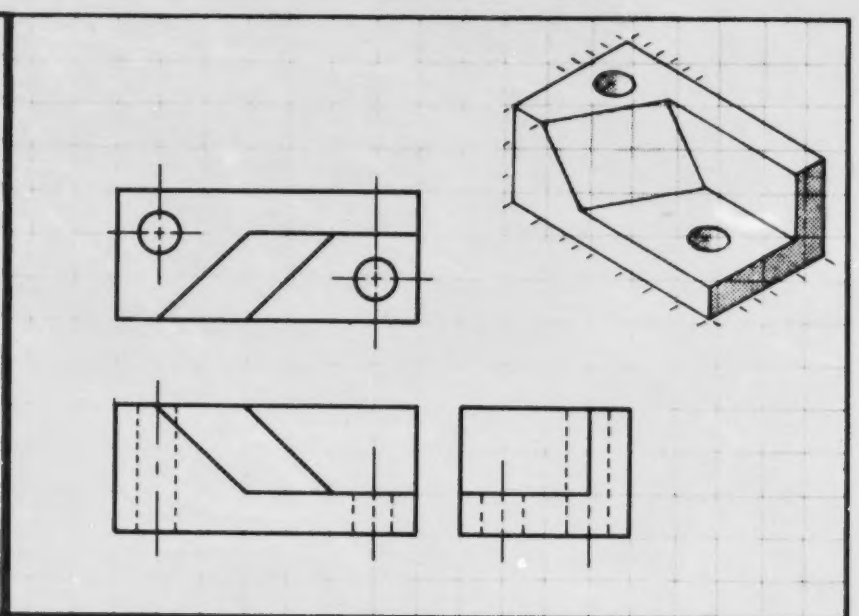
MULTI-VIEW EXERCISE #2

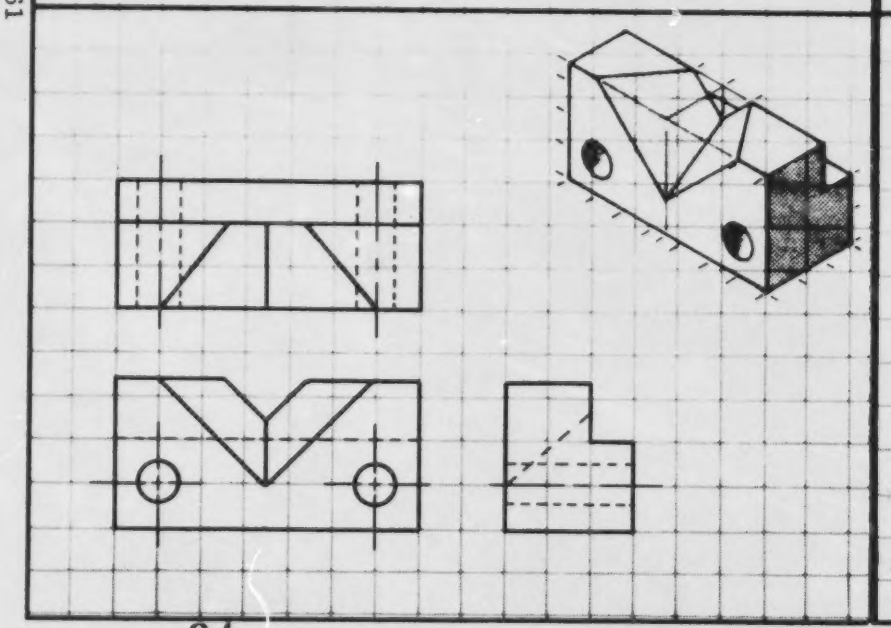
II-B-2a(AS)

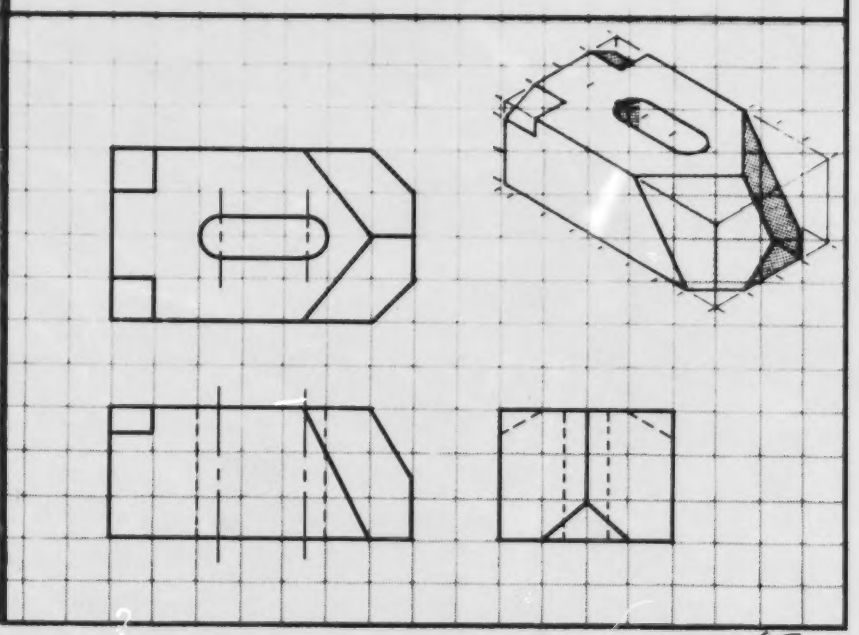
Name:_____

Date:_____









64

65

MATCHING TEST
ON
MULTI-VIEW DRAWINGS

II-B-2(T)
Key
p. 1 of 3

NAME _____ DATE _____

DIRECTIONS: One statement from Column I is closely related to or associated with an item in Column II. Place the capital letter of the associated term in Column II in the blank space at the left of the number in Column I.

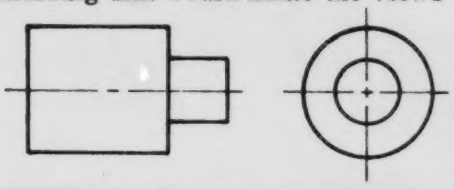
Column I	Column II
E 1. Provides complete size and shape description	A. Plane of Projection
I 2. Relationship of regular views	B. Height
G 3. Projection of front view	C. Principal Dimension
A 4. Imaginary plane perpendicular to line of sight	D. Width
Q 5. Projected onto horizontal plane	E. Multi-View Drawing
L 6. Projection of inclined surface	F. Six
C 7. Height, width, and depth	G. Frontal Plane
F 8. Normal views of an object	H. Depth
N 9. Shows interior features	I. Perpendicular
D 10. Dimension common to front and top view	J. Work Drawing
H 11. Dimension common to top and side view	K. Pictorial Drawing
J 12. Multi-view drawing	L. Auxiliary View
B 13. Principal dimension measured from top to bottom	M. Third Angle
M 14. U.S. standard method of projection	N. Sectional View
P 15. Indicates where part is cut	O. Parallel
	P. Cutting Plane
	Q. Top View

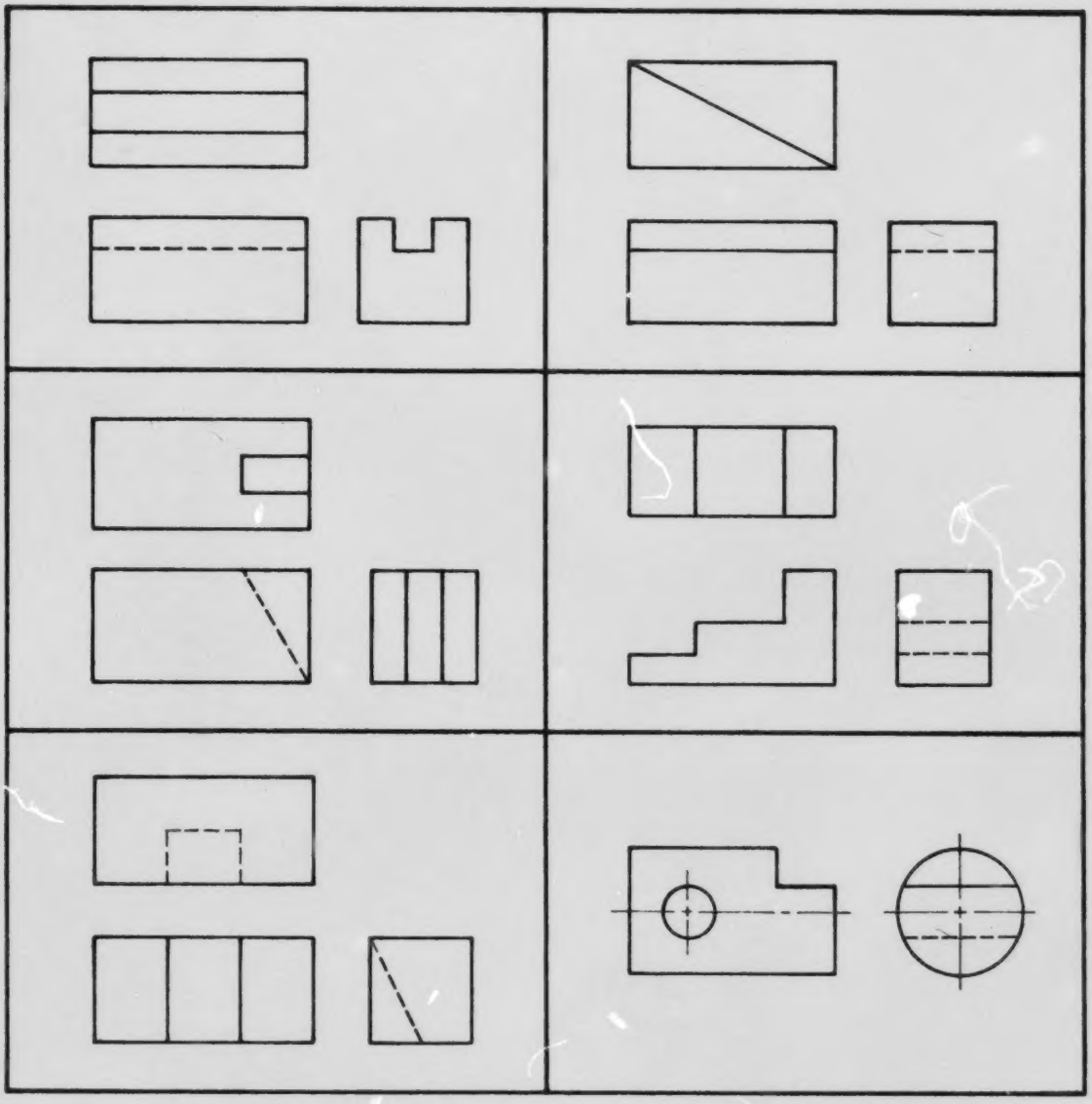
MISSING LINE TEST
ON
MULTI-VIEW DRAWINGS

NAME: _____ DATE _____

DIRECTIONS: In the problems below, study the three views given and sketch in those lines missing that would make the views complete.

EXAMPLE:



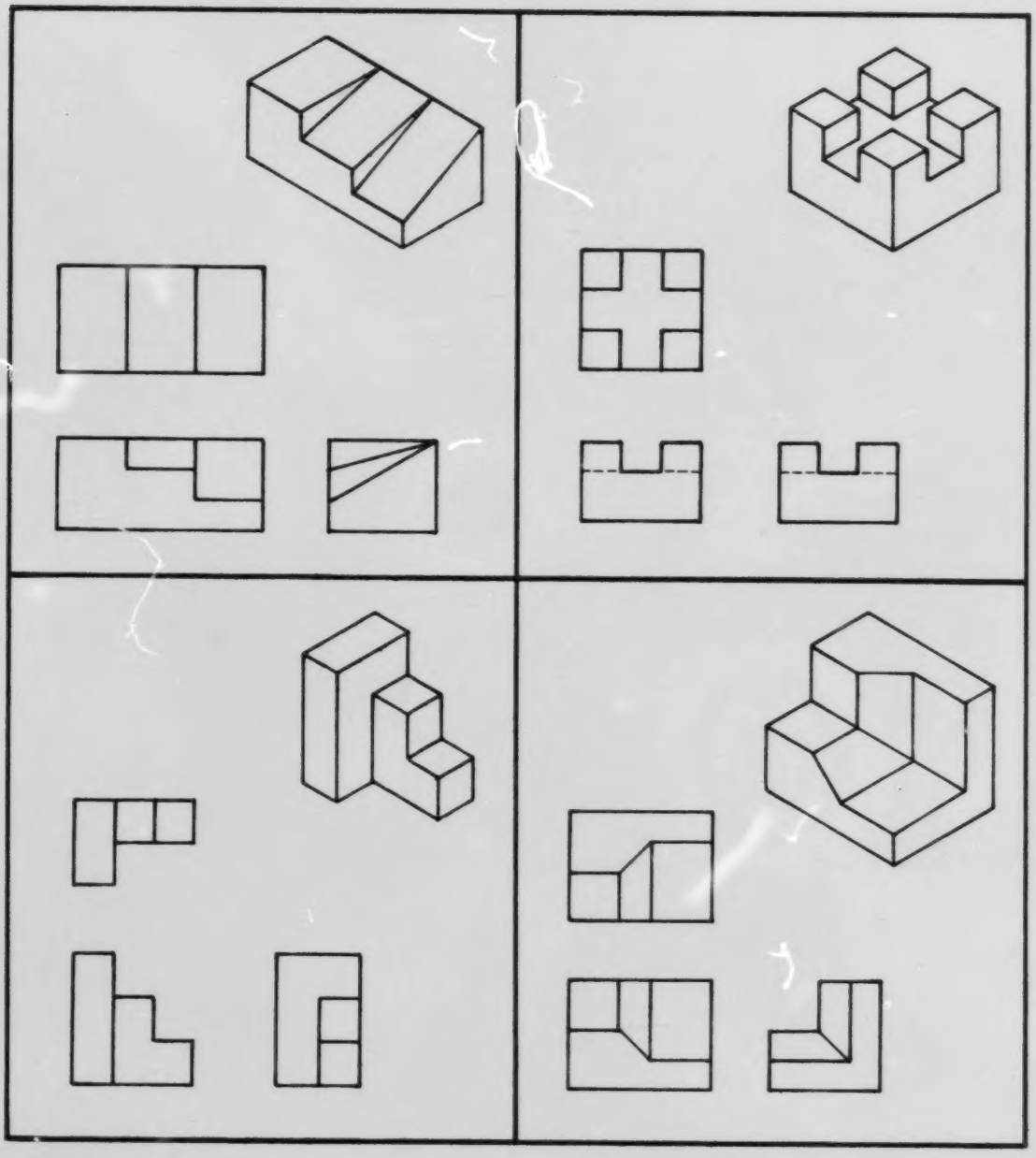


MISSING VIEWS TEST
ON
MULTI-VIEW DRAWINGS

II-B-2(T)
Key
p. 3 of 3

NAME_____ DATE_____

DIRECTIONS: Study carefully the pictorial drawing given in each of the problems below. Sketch all three views of the object in the space provided. Show all visible, hidden, and center lines.



INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

II-B-3(I)

SUBJECT:	Dimensions, Notes and Symbols
AIM:	The student will be able to read and interpret abbreviations, *dimensions, notes, and symbols as they may be applied in reading* a print.
TEACHING AIDS:	Transparencies: I. Ed. M-VII-T, Figures 11-21 Information Sheet: II-B-3(IS) "Dimensions and Dimensioning Practices" Information Sheet: II-B-3a(IS) "Abbreviations, Notes, and Symbols"
MATERIALS:	Chalkboard Overhead projector and screen
REFERENCES:	Basic Blueprint Reading and Sketching Print Reading For Machine Shop Blueprint Reading For Metalworking Trainees Technical Drawing
PREREQUISITE EXPERIENCE OF THE LEARNER:	The student must have completed previous lessons and assignments in print reading.

I. PREPARATION (OF THE LEARNER - MOTIVATION)

In previous lessons we have determined that drawings consist of a series of lines which are used singly or in combination with each other to describe the shape and internal construction of an object. However, for the machinist to construct or machine a part, the drawing or print must include dimensions which indicate exact size and locations of surfaces, indentions, and holes.

These lines and dimensions are supplemented by notes which give additional information such as: the degree of accuracy; kind of material; details regarding assembly of parts and finish; and other data required in the manufacture and assembly of machined parts.

As a means of providing uniformity and continuity in drafting practices, the American Standards Association established practices for size description with the use of dimensions and notes. Although these practices may vary some throughout industry, the basic principle is the same.

In this lesson, dimensioning procedures, symbols, notes, and abbreviations will be studied so that the student may be able to read and interpret a print accurately.

II. PRESENTATION (OF THE INFORMATION)	
INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Dimensions Handout: Information Sheet II-B-3(IS)	1. Gives size description to part 2. Locates geometric figures or surface with each other Note: Give example 3. Provides information concerning: a. Degree of accuracy (tolerance) b. References surfaces c. Machining procedure
B. Types of Dimensions Show: Transparency Figure 11	1. Parts are made up of geometric figures a. Prisms b. Cylinders c. Cones 2. Size of geometric figure given by size dimension 3. Location dimensions give position of the various geometric figures a. Rectangular figures are located with reference to their face b. Cylinders or symmetrical shapes located with reference to their center lines c. Referenced from a finished surface or important center line d. Reference edge is referred to as a datum plane
C. Recording of Dimensions Show: Transparency Figs. 12, 13	Dimensions are recorded in different ways depending on the type of dimension and accuracy of the dimension
1. Fractional Dimensions	1. Given on print in fractional parts of an inch Example: 1 7/8" 2. Used on work not requiring high degree of accuracy 3. Tolerance or limits of work are generally held to $\pm$ 1/64" Example: On a $2\frac{1}{2}$" dimension, minimum acceptable size is 2 31/64". The maximum acceptable size would by 2 33/64" Note: The larger size is referred to as the upper limit. The smaller size is referred to as the lower limit.

4. Tolerance or limits may be given:
   a. On dimension - $3\frac{1}{2} \pm 1/64$
   b. On drawing as note
      Example: Unless otherwise specified: Limits on fractional dimensions are $\pm$ 1/64"

2. Angular Dimensions

1. Angles are dimensioned in degrees (^{o}) or parts of a degree
2. Each degree is one-th[illegible] hundred sixtieth of a circle (1/360)
3. One degree is divided into sixty (60) units called "minutes" (')
4. Each minute (') consists of sixty (")
   Example: 17^{o} 36' 15"

Show: On chalkboard illustrate example and symbols

5. Tolerance or limits are given:
   a. On drawing - $60^{o} \pm 15'$
   b. In a note on drawing
      Example: Unless specified: Limits on angular dimensions are $\pm$ 15'

Show: Sample of angular tolerance
Upper limit: $60^{o} + 15' = 60^{o}\ 15'$
Lower limit: $60^{o} - 15' = 59^{o}\ 45'$

3. Decimal Dimensions

1. Required for high degree of accuracy and precision
2. Computations are easy to make
3. Required use of precision instruments for measurement
4. Dimensions are read in:
   a. Hundredths - .01
   b. Thousandths - .001
   c. Ten-thousandths - .0001
5. Tolerances or limits are applied:
   a. As note on drawing
   Example: Unless otherwise specified: Limits on decimal dimensions are $\pm$ .005"
   b. On dimension
   Example: 3.750" $\pm$ .002"
   Upper limit: 3.750" + .002" = 3.752"
   Lower limit: 3.750" - .002" = 3.748"

   Example: $3.750'' \begin{matrix} +.002 \\ -.004 \end{matrix}$
   Upper limit: 3.750" + .002 = 3.752
   Lower limit: 3.750" - .004 = 3.746

Example: 3.752" - Upper limit
3.746" - Lower limit

Note: This type of dimensioning is referred to as limit dimensioning

6. Decimal dimensions in hundredths simplifies working with fractions

Example: .31 replaces 5/16"
4.50 replaces 4½"

Note: Requires a rule in tenths

D. Scale of Drawing

Show: Transparency
Figure 14

1. Size of drawing made on print
2. Drawing may be full size or scaled to different size
   a. 1" = 1" - full size
   b. 1" = 2" - half size
   c. 2" = 1" - double size
3. Scaled/down to fit drawing on sheet
4. Scaled to increase size for clarity
5. Scale is given in title box
6. Enlarging or reducing has no effect on dimensions

Note: Dimensions give actual size

E. Notes

Show: Transparency
Figure 14

1. Supplement direct dimensions
2. Classified into two types
   a. General notes
   b. Local notes

1. General Notes

1. Apply to the entire drawing
2. Located in following position
   a. Lower right hand corner of drawing
   b. Above or to the left of title block
   c. Central position below view to which they apply
3. Contain information pertaining to:
   a. Material
   b. Heat treatment
   c. General tolerances
   d. Concentricity
   e. Finish or plating data
   f. Anything performed to the outside of the part other than machining

Show Examples:

F.A.O. - Finish all over
Break all sharp edges
Dimensions apply after plating

2. Local Notes

1. Apply to specific operations

Show: Transparency
Figure 15 and 16

2. Connect with a leader line to point operation is to be performed
   Example: .25 drill - 4 holes equally spaced
3. Use common abbreviations frequently
   Example:
   Thread - THD
   Diameter - DIA or D
   Countersink - CSK or CSINK
   Note: Emphasize importance in knowing print abbreviations

F. Symbols

1. Provides information that is not conveyed either by views or dimensions
2. Consist of four forms
   a. Finish symbols
   b. Material symbols
   c. Thread symbols
   d. Auxiliary symbols

1. Finish Symbols

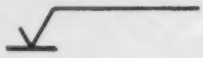
Show: Transparency
Figure 17, 18, 19

1. Applies to surface that requires material removed in order to improve:
   a. Size
   b. Smoothness
   c. Geometry
      Note: Concentricity or squareness of an object
2. Applied to edge view of a surface
3. Determines the type of finish required
   Note: Material type and contour and finish required determine machining process
4. Contain two basic types of finish marks
   a. Non-Control - There is no control over surface quality indicated
      (1) Indicates smooth or machined finish
      (2) May be classified by letter or number
      (3) Symbol may be a "$\checkmark$" or "$\vee$" shape either alone or marked with a letter

Show Example: "M" for machined or "G" for ground

   Note: Although still used, this method is obsolete
   b. Control - Control of finish quality is required - measured in microinches
      (1) Quality of finish depends on height, width, and direction of surface irregularities

(2) Standardized symbol is a check mark or radical

Show Example: 

(3) Numerical value placed in the check mark refers to roughness height of finish

Show Example:

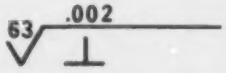
(4) Roughness of finished surface is measured by a profilometer in microinches

(5) Readings form the profilometer are referred to as root mean square (RMS)

(6) RMS is determined by the average reading taken on a profilometer

(7) Additional values and markings may be used to indicate type, direction, and surface irregularities

Note: Includes roughness, waviness, and lay of surface finish

Show Example: 

Explain: 63 - Roughness height measured in microinches
.002 - Maximum waviness height measured in thousandths
- Lay of surface pattern produced by tool marks

2. Material Symbols

1. Represent sectioned or interior parts from the surfaces
2. Distinguish different types of material in an assembled view
3. Represent the general type of material

Note: Specific material specified by note or in title box

4. Cast iron is the general purpose symbol used for all materials

Show: Transparency Figure 20

3. Thread Symbols

1. Illustrate two types of threads
   a. External
   b. Internal

2. Represent threads in three different ways:
   a. Graphically - as the thread actually appears

Show: Transparency Figure 21

   Note: Method is not practical and seldom used
   b. Conventionally - referred to as the regular method of thread representation or schematic
   c. Simplified - most common method used

4. Auxiliary Symbols
   1. Are used in mathematic calculations
   2. Provide condensed means of writing specifications of materials

G. Abbreviations
   1. Review abbreviations
   2. Explain meaning of each
   3. Abbreviations may vary with different companies

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION).

1. Students identify the various geometric figures.
2. Students identify size and location dimensions.
3. Student explain purpose in the use of location dimensions.
4. Student discuss the importance of limits applied to dimensions.
5. Students read dimensions from a drawing.
6. Student identify notes, symbols, and abbreviations.
7. Students complete assignment sheets on reading dimensions, notes, and symbols.

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENTS' COMPREHENSION OF MATERIALS PRESENTED).

Simple Recall

1. The location of one geometric figure with respect to another is given by a location dimension.
2. Cylinders or symmetrical shapes are located with reference to their center line.
3. A reference edge is commonly referred to as a datum plane.
4. Three types of geometric figures that make up a drawing are: (1) cones; (2) cylinders; and (3) prisms.
5. A dimension giving the diameter of a circle is referred to as a size dimension.

6. Dimensions on parts that do not require a high degree of accuracy are given in fractions.
7. Angular dimensions are recorded in degrees.
8. Parts dimensioned in decimals require the use of precision measuring instruments.
9. The amount of variation permitted in the size of a part is called the tolerance.
10. The smallest or largest acceptable size that a part can be machined is called the limit.

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT).

1. The purpose of dimensions is to:
   1. Give size description to the part
   2. Locate geometric figures or surfaces
2. Two types of dimensions are:
   1. Location dimension - locates two geometric surfaces
   2. Size dimension - gives size of a surface
3. Dimensions may be recorded as:
   1. Fractions
   2. Angles
   3. Decimals
4. Notes are used to supplement direct dimensions and are classified as:
   1. General notes - apply to entire drawing
   2. Local notes - apply to a specific operation
5. Symbols provide information that is not conveyed by either views or dimensions and consists of four forms:
   1. Finish symbols
      a. Control - controls type finish required
      b. Non-control - specifies only that surface be machined
   2. Material symbols
   3. Thread symbols
      a. Graphical
      b. Conventional
      c. Simplified
   4. Auxiliary symbols
6. Tolerances or limits are applied to dimensions to provide acceptable maximum and minimum sizes.

SUGGESTED READING FOR STUDENT:

II-B-4(IS) "Principles of Sectional Views"

The Next Lesson Is: II-B-4 "Sectional Views"

INFORMATION SHEET
ON
PRINT READING

II-B-3(IS)

SUBJECT: Dimensions and Dimensioning Practices

INTRODUCTORY INFORMATION:

Drawings consist of lines that describe the exterior shape and internal construction of an object. However, for that object to be constructed or machined, the drawing must provide information as to the exact size and location of surfaces, holes, and configurations.

Dimensions on a drawing should be complete to the point that a minimum amount of computation will be required and the part may be made without scaling the drawing.

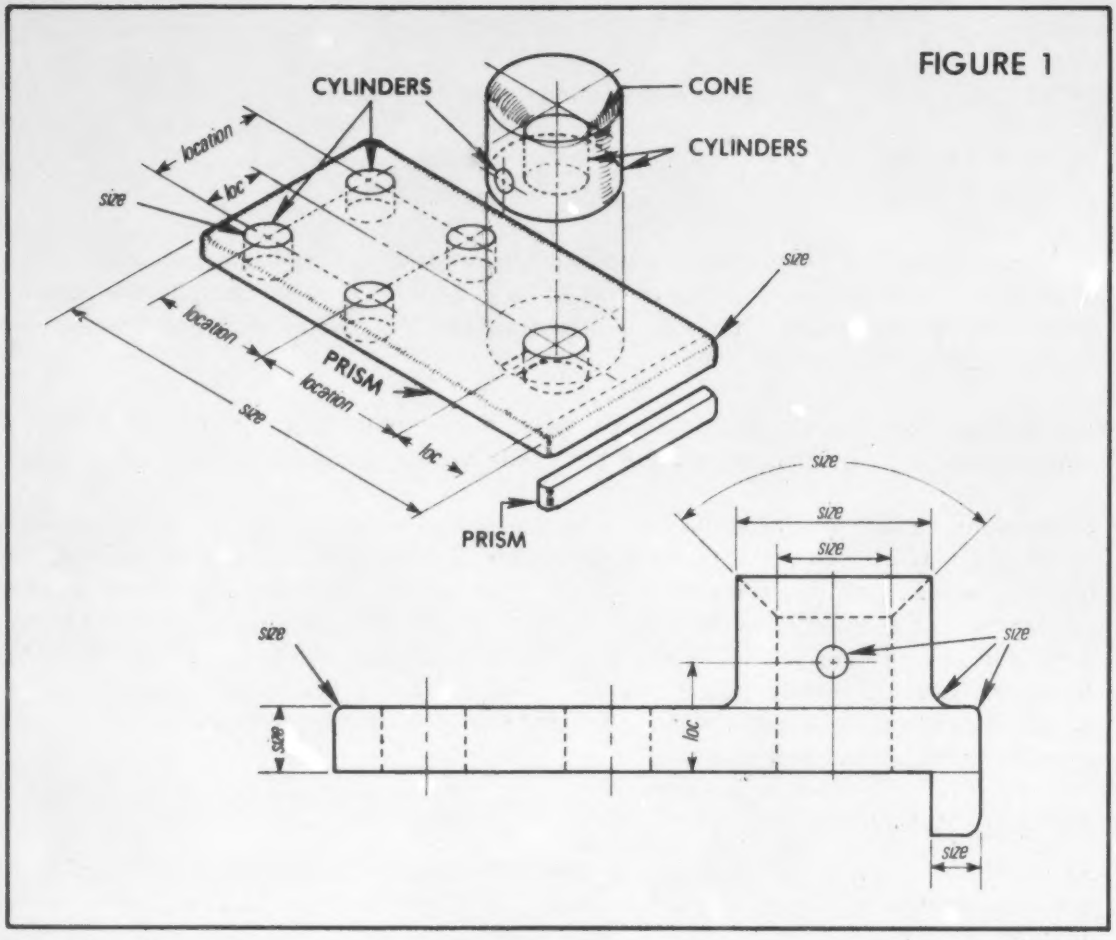
Some parts cannot be drawn full size because they are too large to fit the drawing sheet, or may be too small to show all details clearly. In cases such as this, the drawing is enlarged or reduced by letting one unit of measure represent another. An example of this would be letting 1" = 2" to reduce the size or have 2" = 1" to enlarge the size of the part. The scale of the drawing can be found in the title box. An example would be: Scale: 2" = 1". However, this practice of enlarging or reducing the size of the drawing does not affect any of the dimensions as the dimensions give the actual sizes of the part.

Types of Dimensions

As previously stated, dimensions are used to give information as to size and location of geometric figures, such as, prisms, cylinders, cones, pyramids, and spheres, as seen in Figure 1.

In dimensioning an object, the dimensions must give the size of each geometric figure, "size dimensions," and the exact location of each surface, "location dimension." For example, to drill a hole in a part, the machinist must know three things: (1) the diameter of the hole (size dimension); (2) the exact location of the center (location dimension), and (3) depth of hole. These basic dimensions can be broken down into four types of dimensions given that are required in reading the drawing. These dimensions are: (1) overall dimensions of the part; (2) shape dimensions of each geometric figure; (3) location dimensions, locating each geometric figure with each other or a reference edge; and (4) notes or descriptors, that give information as to size and procedure. Example: ½ drill 3/4" deep - 4 holes, as in Figure 1.

In general, size dimensions give a complete description of a surface while location dimensions gives the location of a surface from a finished surface, given as a datum plane, or from an important center or center line.



Dimensioning

In dimensioning an object, the way the dimension is recorded is determined by the degree of accuracy required and the type of dimension. Generally speaking, dimensions are recorded in fractions, decimals and by degrees. As industry converts more and more to the metric system, the use of metric dimensions will be used. For the present we will concern ourselves with the use of the English System.

Fractional Dimensions, commonly referred to as "scale dimensions," are called for where a high degree of accuracy is not required. Accuracy of this type of dimension is usually held to a $\pm$ 1/64" of the given dimension. This is called the tolerance of a dimension and as long as the finished part is within the maximum and minimum limits it is acceptable. That is to say, on a part with a specified dimension of 6 7/8", the maximum acceptable size (limit) would be 6 7/8" + 1/64" = 6 57/64"; the minimum acceptable size (limit) would be 6 7/8" - 1/64" = 6 55/64". Therefore, as long as the finished size is within these limits it is acceptable. The tolerance for fractions are usually accepted as $\pm$ 1/64" unless otherwise specified. This will normally be noted in the title box.

Decimal Dimensions

Decimal dimensions may be expressed in hundredths of an inch (.01"), thousandths of an inch (.001"), ten-thousandths of an inch (.0001"), and, occasionally, in hundred-thousandths of an inch (.00001"). Formerly, decimal dimensions were used where a high degree of accuracy was required, but the use of decimal dimensions in hundredths of an inch to replace the fractional dimension is becoming popular. In other words, .14" would replace 9/64" or 3.06" instead of 3 1/16". Example: ⟵ 3.06 ⟶ Where decimal dimensions are used in place of fractions, the same tolerance (1/64" or .016") is used.

Decimal dimensions in thousandths are used on parts requiring a greater degree of precision with less tolerance. The tolerance given to the dimension is determined by how precision the part must be. An example of this would be the dimension 2.625 ± .0004. The tolerance ± .004" means that the size of the part can be from 2.629" (maximum limit) to 2.621" (minimum limit). Thus the part is acceptable if it measures between 2.629" and 2.621".

Tolerance dimensions may be given as a note in the title box as: "Unless otherwise specified limits on decimal dimensions are ± .005 inches," or on the drawing by one of three ways, as in examples below:

1. ⟵ 2.250±.002 ⟶

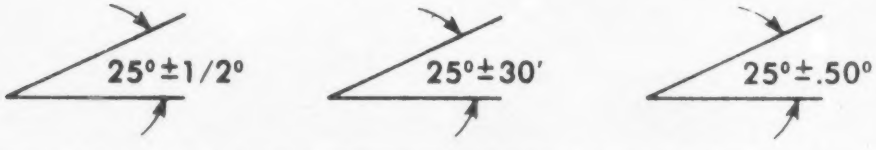
2. ⟵ $\frac{2.252}{2.248}$ ⟶

3. ⟵ $2.252\ ^{+.000}_{-.004}$ ⟶

In each of the above dimensions the tolerance is .004", the difference between the maximum limit and minimum limit.

Angular Dimensions

The size of angles are expressed in degrees (°) or parts of a degree, such as minutes (') and seconds ("). Angular tolerances may be given in the dimension as below:



In this example, the finished angle may be as much as 30 minutes above or below the specified angle.

The tolerance of angles may also be given in note form in the title box as: "Unless otherwise specified limits on angular dimensions are ± 2°".

INFORMATION SHEET
ON
PRINT READING

II-B-3a(IS)

SUBJECT: Abbreviations, Notes, and Symbols

INTRODUCTORY INFORMATION:

In a working drawing, it is often necessary to provide additional information which cannot be conveyed either by views or conventional dimensions. This information may consist of such items as: kind of material; type or degree of finish; operations, such as drill, ream, broach, or countersink; and the representation of threaded parts. To write out the information would not only be lengthy, but would create confusion in the reading and interpretation of the drawing. Through the use of notes, symbols, and abbreviations, the required information is given in a simple and distinct way.

To insure that the abbreviations, notes, and symbols used will have the same meaning, the American Standards Association provides a listing of those that are commonly used and accepted.

GENERAL INFORMATION

Abbreviations

Listed below are abbreviations of common terms that the machinist will come in contact with in reading prints.

Word or Term	Abbreviation
Addendum	ADD
Adjust	ADJ
American Institute of Iron and Steel	A.I.S.I.
Allowance	ALLOW
Alloy	ALY
Alternating Current	AC
Aluminum	AL
American Standard	AMER STD
American Wire Gage	AWG
Angle	ANG
American National Pipe Thread	ANPT
American Welding Society	AWS
Approximate	APPROX
Area	A
Assemble	ASSEM
Assembly	ASSY
Auxiliary	AUX

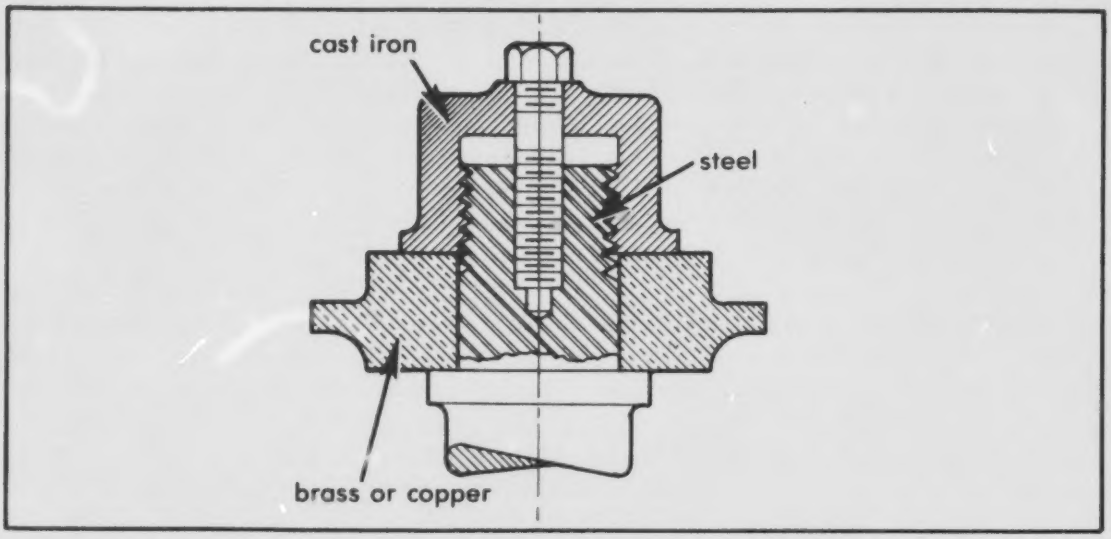
Word or Term	Abbreviation
Babbitt	BAB
Ball Bearing	BB
Bearing	BRG
Bill of Materials	B/M
Bolt Circle	BC
Brass	BRS
Break	BRK
Brinell Hardness Number	BH
Broach	BRO
Bronze	BRZ
Brown and Sharpe	B&S
Burnish	BNH
Cadmium	CAD
Carburize	CARB
Case Harden	CH
Cast Iron	CI
Cast Steel	CS
Casting	CSTG
Center	CTR
Center Line	CL
Chamfer	CHAM (CHF)
Chordal	CHOR
Circle	CIR
Circular Pitch	CP
Clearance	CL
Clockwise	CW
Cold Drawn	CD
Cold Drawn Steel	CDS
Cold Finish	CF
Corrected	CORR
Cosine	COS
Cotangent	COT
Counterbore	C'BORE
Countersink	C'SINK (CSK)
Counterclockwise	CCW
Counterdrill	C'DRILL
Dedendum	DED
Degree	DEG
Diagonal	DIAG
Diameter	DIA (d) (D)
Diametral Pitch	DP
Dimension	DIM
Double	DBL
Drawing	DWG
Drill	DR

Word or Term	Abbreviation
Eccentric	ECC
Feet Per Minute	FPM
Figure	FIG
Finish All Over	FAO
Fixture	FIX
Flat Head	FH
Forged Steel	FST
Full Indicator Reading	FIR
Gage	GA
Grind	GRD (G)
Harden	HDN
Head	HD
Heat Treat	HT
Hexagon	HEX
High Speed Steel	HSS
Height	HT
Horizontal	HOR
Hypotenuse	HYP
Included	INCL
Inside Diameter	ID
Inspection	INSP
Keyseat	KST
Keyway	KWY
Left Hand	LH
Linear	LIN
Locate	LOC
Machine	MACH
Magnaflux	M
Magnesium	MAG
Material	MATL
Maximum	MAX
Minimum, minute	MIN
National	NATL (N)
National Coarse Thread	NC (UNC)
National Extra Fine Thread	UNEF NEF
National Pipe Thread	NPT
Nominal	NOM
Not to Scale	NTS
Number	NO
On Center	OC
Outside Diameter	OD
Overall	OA
Pattern	PATT
Pitch	P
Pitch Diameter	PD

Word or Term	Abbreviation
Plate	PL
Pounds Per Square Inch	PSI
Profile	PF
Radial	RAD
Radius	R
Ream	RM
Reduction	RED
Reference Line	REF L
Relief	REL
Revised	REV
Revolution Per Minute	RPM
Right Hand	RH
Rockwell Hardness	RH
Root Diameter	RD
Root Mean Square	RMS
Schedule	SCH
Screw	SCR
Shaft	SFT
Sheet	SH
Society of Automotive Engineers	SAE
Specifications	SPEC
Spot Face	SF
Standard	STD
Stainless Steel	SST
Surface	SUR
Symmetric	SYM
Tangent	TAN
Taper	TPR
Taper Per Foot	TPF
Tensile Strength	TEN/STR
Thread	THD
Threads/Teeth Per Inch	TPI
Total Indicator Reading	TIR
Tolerance	TOL
Tooth	T
Typical	TYP
Universal	UNIV
Vertical	VERT
Volume	VOL (V)
Weight	WT
Weldment	WELD
Woodruff	WDF

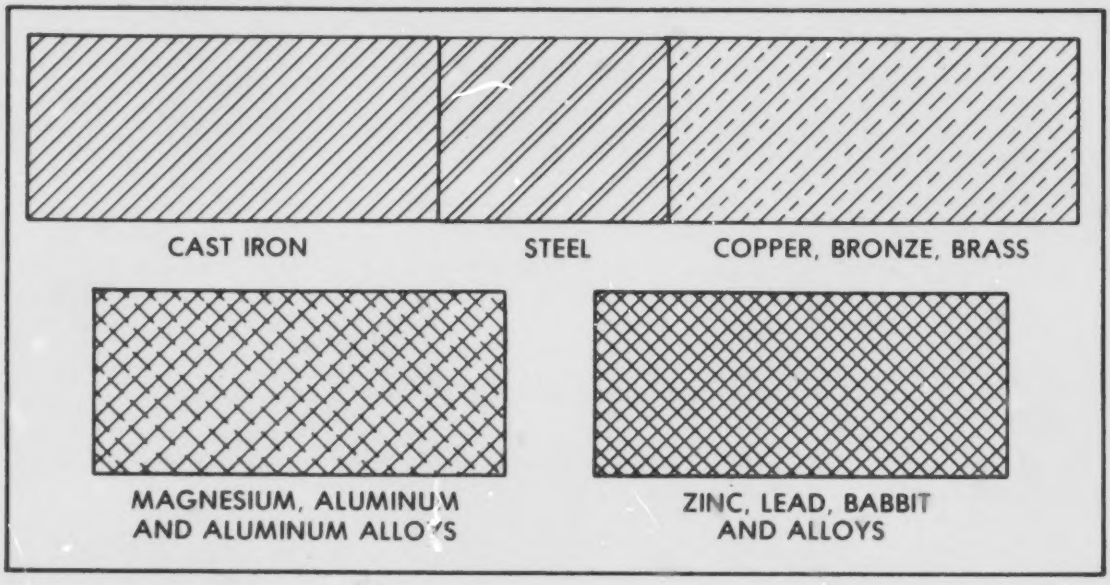
Material Symbols

In sectional views it is useful and convenient to distinguish the interior or sectioned part (material) the object from the machined surfaces. Conventional material symbols are used to show the interior part and also in clarifying sections where more than one kind of material is used, such as in assembled drawings. See Figure 1.



It is important to understand that material symbols represent the kind of material, but the exact composition, such as an alloy, is specified on the drawing by means of a note. Also, for most applications, the symbol for cast iron is used as a general purpose material symbol.

The most frequently used symbols are as follows:



Finish Symbols

The term "finished surface" applies to any surface that requires the removal of material to improve its shape, size, or smoothness. This is done by various machining processes such as turning, milling, drilling, grinding, broaching, or shaping.

A finish mark is used to indicate a surface that is to be machined or finished, such as on a rough casting. On drawings where the part is to be machined from rolled stock, finish marks would not be necessary as it is obvious that the surface is finished. An exception to this rule is where either the type of finish is called for, such as the noncontrol method which only specifies a finished surface (V) or the controlled finish which specifies the accepted finish in microinches (MU in. .000001), which is the present practice ($\sqrt{60}$). This method may also include the designation of maximum waviness height, maximum waviness width, and lay, or direction of predominant surface pattern ($\sqrt{63}\ \frac{002}{\perp\ 100}$).

Modern inspection equipment, such as profilometers, which measure the irregularities. One method is the Arithmetical Average Height, which is the average of the total number of vertical measurements (Ave. Height = $\frac{A_1 + A_2 + A_3 + A_4}{4}$).

The second method is the root mean square (RMS), which is the number of readings taken on a profilometer squared (usually five) divided by the number of readings. RMS = $\frac{\sqrt{A^2 + B^2 + C^2 + D^2}}{N}$

BOTH OF THESE METHODS CAN BE MEASURED ON THE PROFILOMETER.

The following illustrations are examples of finish marks used in drawings and their meanings.

Noncontrol Finish Marks

$\sqrt{}$ or $\underline{V}$ - indicates only that surface is finished

$\sqrt{G}$ - indicates the surface is to be ground

$\sqrt{M}$ - indicates only a machined surface

Control Finish Marks - Controls finish quality in terms of height, width, and direction of surface irregularities. The control finish mark may include all or part of the following notes:

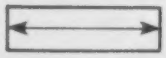
$\sqrt{}$ - Radical represents finished surface

$\sqrt{63}$ - Number represents roughness height measured in microinches (MU in.)

.002 - Represents maximum waviness height of surface irregularities measured in thousandths

⊥ - Represents lay of surface as produced by direction of tool mark May consist of one of the following:

⊥ - Perpendicular

|| - Parallel 

X - Angular

M - Multidirectional

C - Circular

R - Radial

Micro Finish	Operation Performed
1-16	Scraped, lapped, or very fine ground
17-32	Fine turned, reamed, or ground
33-125	Medium turned, reamed, or ground
126-250	Rough turned, ground, milled, planed, or sawed
251-500	Very rough turned, milled, planed, or sawed

Auxiliary Symbols

In addition to the abbreviations and symbols that are used on prints or specification sheets, there are auxiliary type symbols that are used in the machinist trade. These symbols may be used on the print, specification sheets, or in material listings and calculations.

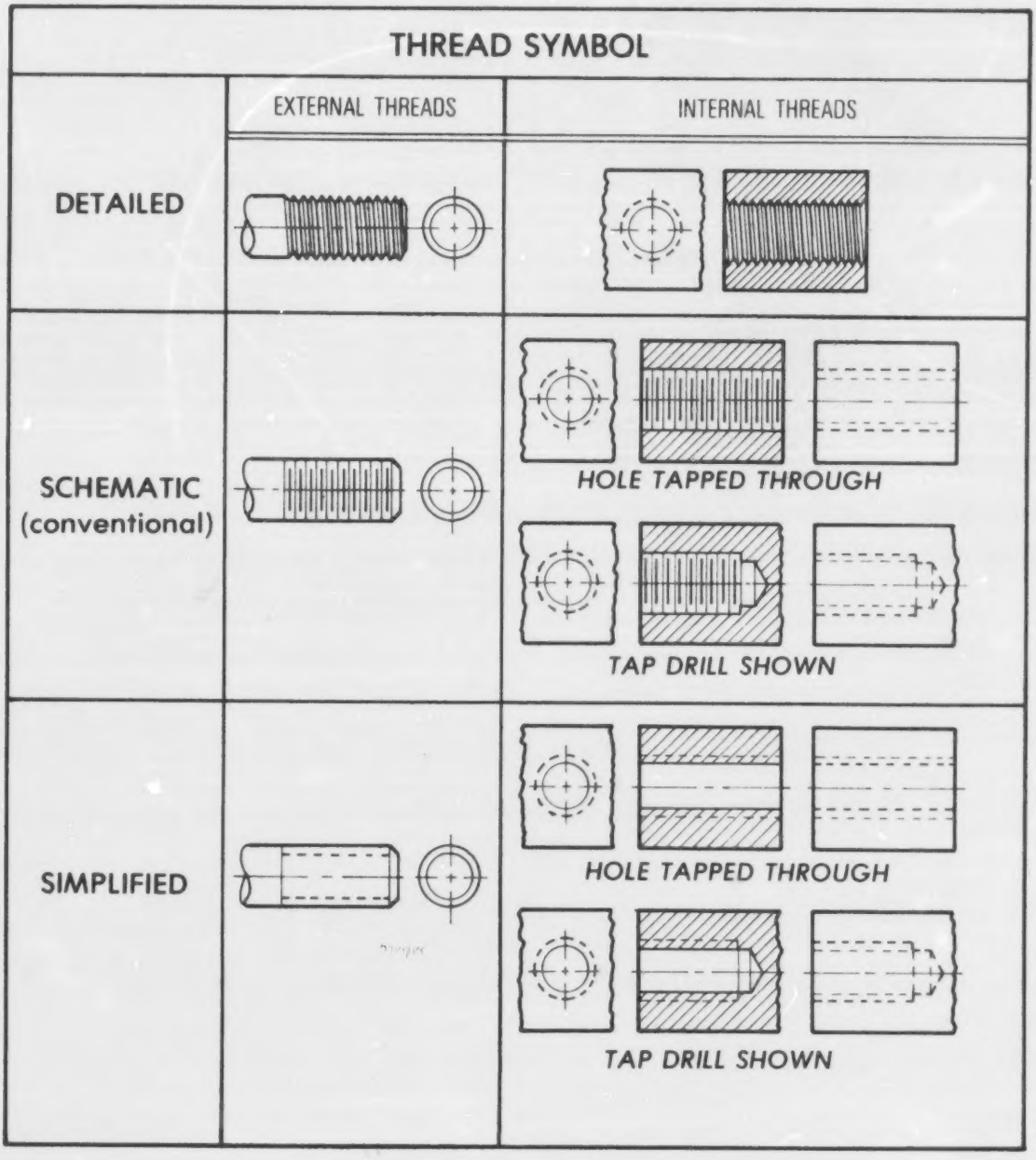
Below is a list of some of the more frequently used symbols and their meaning.

Symbol	Meaning
& or ℄	And
∠	Angle
⌒	Arc

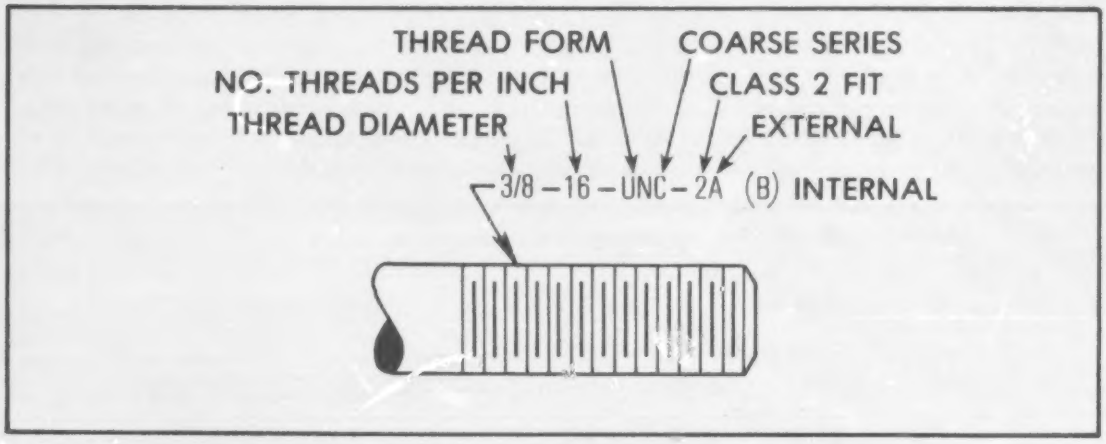
Symbol	Meaning
℄	Center Line
⊙	Circle
°	Degrees
÷	Divide (into)
=	Equal
′	Feet or Minutes
″	Inches or Seconds
−	Minus (subtract)
//	Parallel
+	Plus (add)
%	Percent
⊥	Perpendicular
π	Pi (3.1416")
:	Ratio (is to)
ϕ	Round Bar or Diameter
⌀	Square Bar or Square
×	Times (multiply)
△	Triangle
◺	Right Triangle

Thread Symbols

Thread symbols are used to represent threads of small diameter, usually one inch diameter or less, on the drawing. The symbols used are the same regardless of the form of thread, as Acme, American National, and Unified. There are two approved sets of symbols used, with choice a matter of company standards. For threads one inch and smaller the sets used are: (1) Schematic (Conventional) and (2) Simplified. On large threads, a graphic or detailed representation is used. See the following illustrations.



Regardless of the method of representation used, the thread is specified by means of a standard notation which provides information concerning the thread, as illustrated in the figure below.



Notes

Notes are used to supplement the direct dimensions. They are brief, sometimes abbreviated or containing symbols, and are carefully worded to provide only one interpretation. Notes are classified into general notes and local notes.

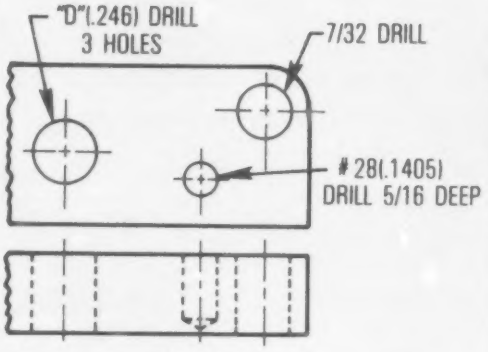
General notes are located in the title block. Above or to the left of the title block or below the view to which they apply. See Figure below.

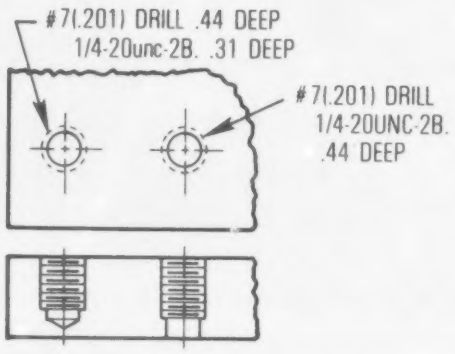
NO.	CHANGE	DATE	BY	QTY.	ORDER NO.		DWG. BY	CK. BY	APP. BY
				12	V-627	8/1/82	SCALE: 1=1	MAT. SAE 3140	L.R.

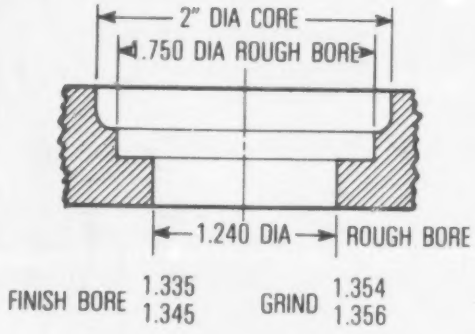
UNLESS OTHERWISE SPECIFIED:	LOWER DRUM SHAFT	
limits on decimal dimensions within ± .005"	FINISH:	
limits on fractional dimensions within ± 1/64"	FINISH ALL OVER	
limits on angular dimensions within ± 1/2°	BREAK ALL SHARP EDGES	A-121

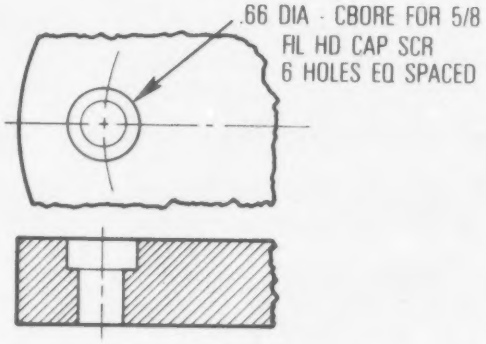
Local notes apply to specific operations and are connected with a leader line to the point at which such operation is performed. Abbreviations are frequently used. In the following figures are examples of common local notes that are used on drawings.

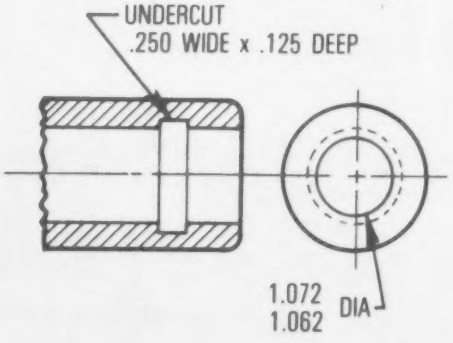
LOCAL NOTES

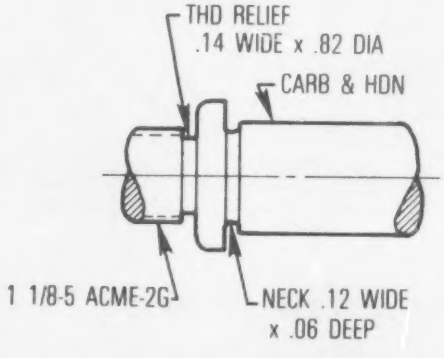

"D"(.246) DRILL
3 HOLES
7/32 DRILL
28(.1405)
DRILL 5/16 DEEP


7(.201) DRILL .44 DEEP
1/4-20unc-2B. .31 DEEP
7(.201) DRILL
1/4-20UNC-2B.
.44 DEEP

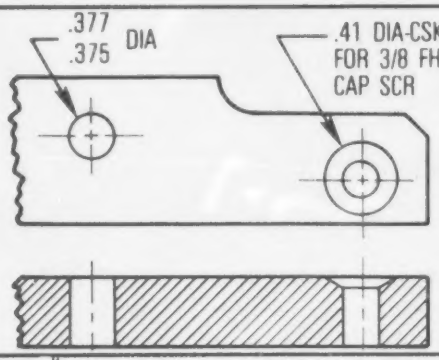

2" DIA CORE
.750 DIA ROUGH BORE
1.240 DIA
ROUGH BORE
FINISH BORE 1.335
1.345
GRIND 1.354
1.356

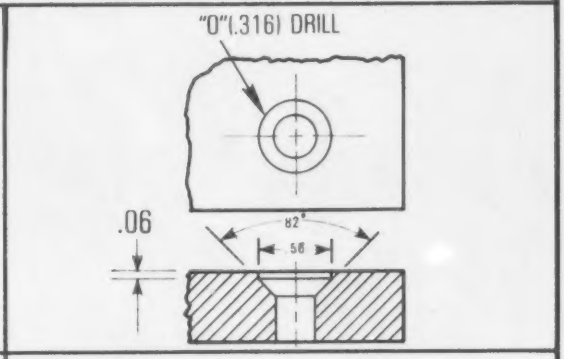

.66 DIA - CBORE FOR 5/8
FIL HD CAP SCR
6 HOLES EQ SPACED

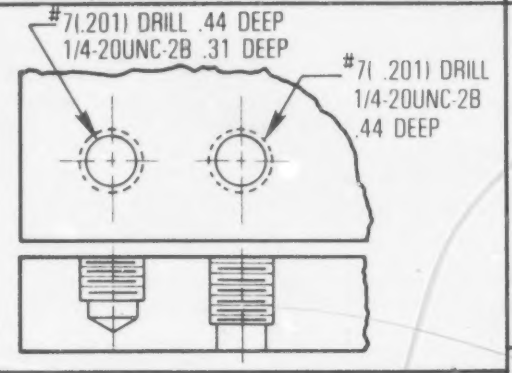

UNDERCUT
.250 WIDE x .125 DEEP
1.072
1.062
DIA

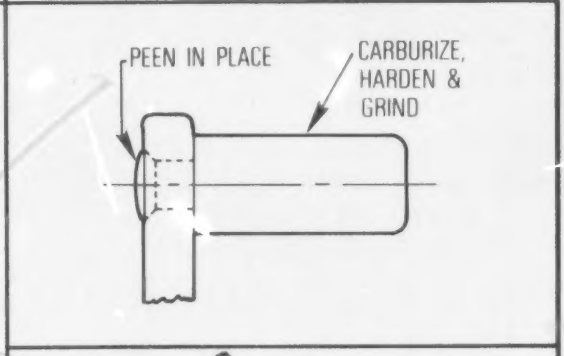

THD RELIEF
.14 WIDE x .82 DIA
CARB & HDN
1 1/8-5 ACME-2G
NECK .12 WIDE
x .06 DEEP

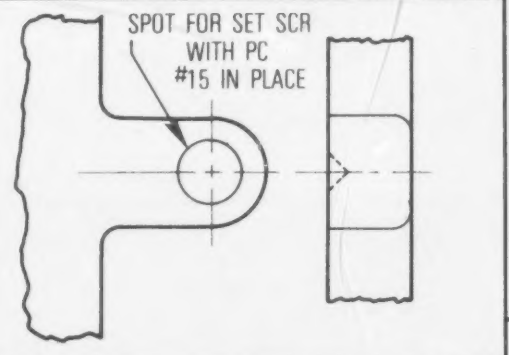
LOCAL NOTES

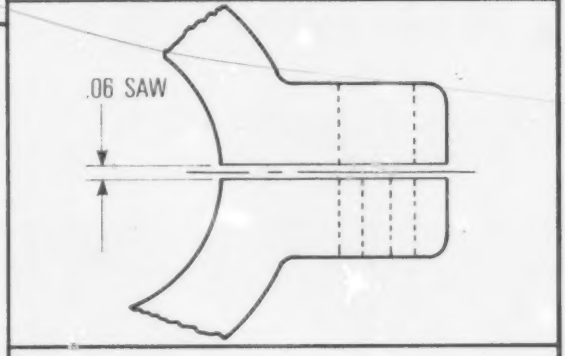

.377
.375 DIA
.41 DIA-CSK
FOR 3/8 FH
CAP SCR

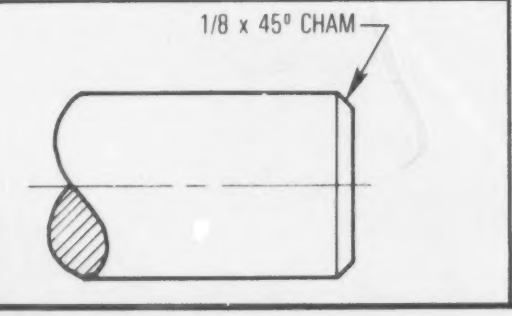

"O"(.316) DRILL
.06
82°
.56

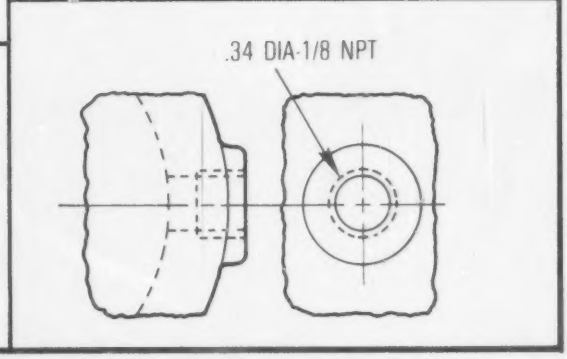

#7(.201) DRILL .44 DEEP
1/4-20UNC-2B .31 DEEP
#7(.201) DRILL
1/4-20UNC-2B
.44 DEEP


PEEN IN PLACE
CARBURIZE,
HARDEN &
GRIND

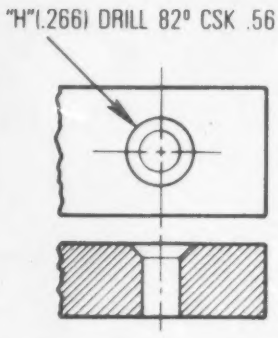

SPOT FOR SET SCR
WITH PC
#15 IN PLACE

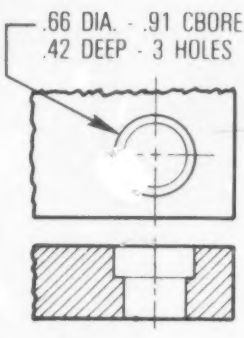

.06 SAW

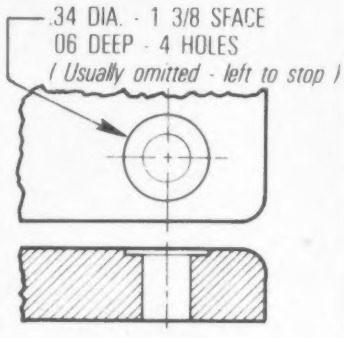

1/8 x 45° CHAM

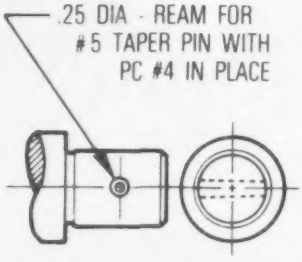

.34 DIA-1/8 NPT

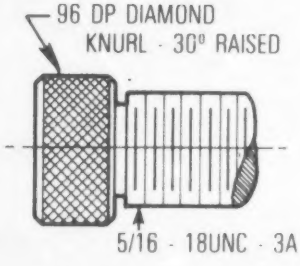
LOCAL NOTES

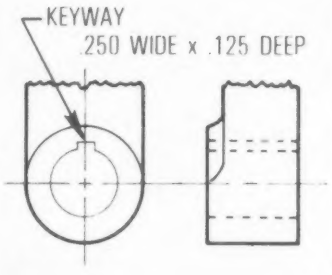

"H"(.266) DRILL 82° CSK .56 DIA

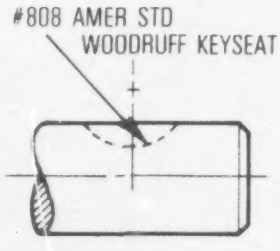

.66 DIA. - .91 CBORE
.42 DEEP - 3 HOLES


.34 DIA. - 1 3/8 SFACE
06 DEEP - 4 HOLES
(Usually omitted - left to stop)

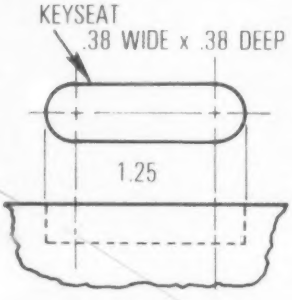

.25 DIA - REAM FOR
#5 TAPER PIN WITH
PC #4 IN PLACE


96 DP DIAMOND
KNURL - 30° RAISED
5/16 - 18UNC - 3A


KEYWAY
.250 WIDE x .125 DEEP


#808 AMER STD
WOODRUFF KEYSEAT

BROACH FOR
#808 AMER STD
WOODRUFF KEY


KEYSEAT
.38 WIDE x .38 DEEP
1.25

ASSIGNMENT SHEET
IN
PRINT READING

II-B-3(AS)

SUBJECT: Interpretation of Dimensions, Notes, and Symbols

AIM: The student will be able to read, interpret, and accurately record information given by dimensions, notes, and symbols from a given print and by identifying abbreviations that are frequently used.

INTRODUCTORY INFORMATION: The ability to visualize an object as it appears on a drawing is not sufficient to manufacture a part. To complete the description of a part requires complete shape description, as in Assignment Sheet II-B-2(AS), and size description. Size descriptions are given by applying dimensions in fractions, decimals, and angles. These dimensions are supplemented by the use of symbols and notes, for the complete interpretation of a print requires the knowledge of how dimensions are given and the ability to interpret notes, symbols, and abbreviations that are used. Prior to working the following assignment, it is important that the student carefully study Information Sheets II-B-3(IS) "Dimensions and Dimensioning Practices" and II-B-3a(IS) "Abbreviations, Notes, and Symbols".

REFERENCES: Information Sheet II-B-3(IS) "Dimensions and Dimensioning Practices"
Information Sheet II-B-3a(IS) "Abbreviations, Notes, and Symbols"

QUESTIONS AND/OR PROBLEMS:

1. Assignment Sheet II-B-3(AS) requires the student to study the print and record the correct answer that corresponds to the given statement.
2. Complete Assignment Sheet II-B-3a(AS) by filling in the blank that corresponds to the given abbreviation, note, or symbol with the term that correctly identifies it.

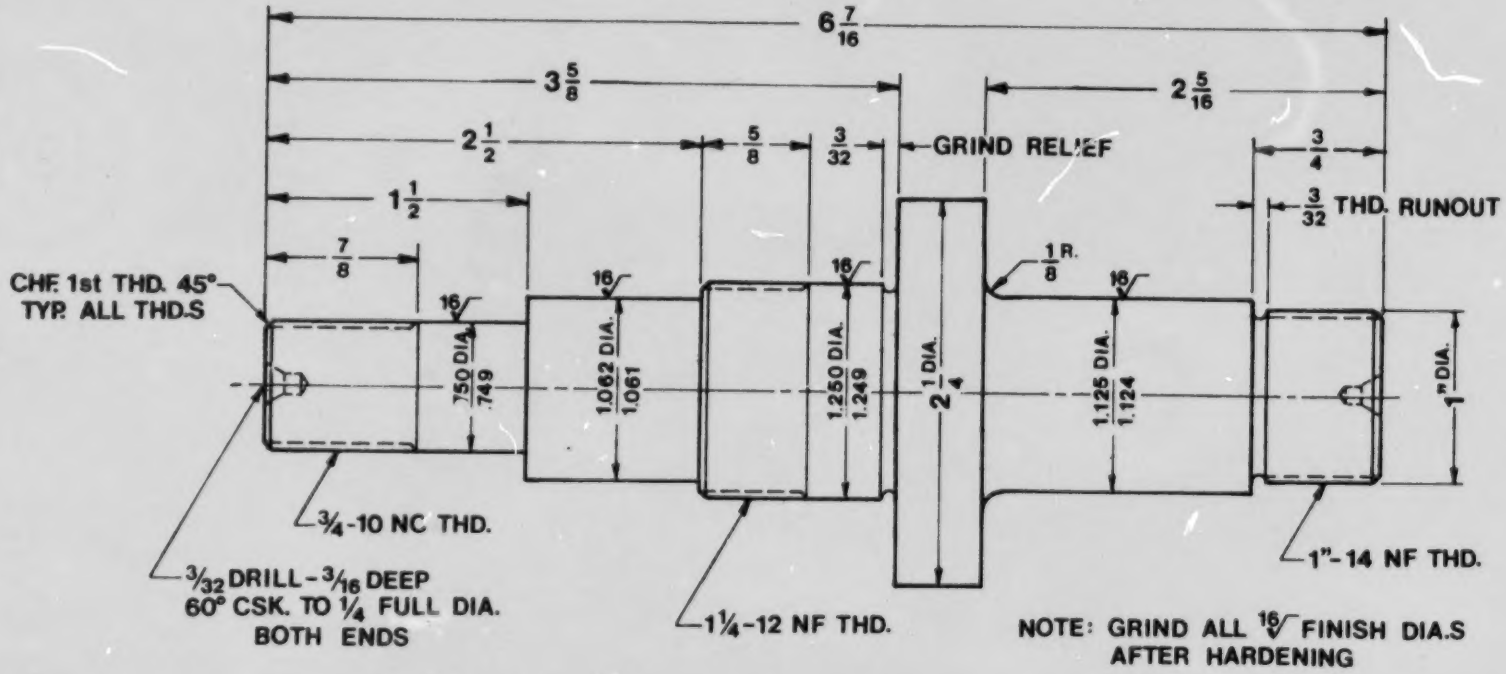
ASSIGNMENT SHEET
ON
DIMENSIONS, NOTES AND SYMBOLS

II-B-3(AS)
Key

NAME_____ DATE_____

DIRECTIONS: Read and interpret the following print by recording the correct answer in the blank corresponding to the statement.

EXAMPLE:	1. Name of part	spindle shaft
1.	Material used	4140 H. R. S.
2.	Maximum size of $2\frac{1}{4}$" diameter	2 17/64
3.	Minimum chamfer angle on threads	$44^{o}45'$
4.	Grind finish required	16
5.	Minimum length of 3/4 -10-NC thread	55/64
6.	Lower limit of 1 1/16" diameter	1.061
7.	Type thread representation	simplified
8.	Length of $1\frac{1}{4}$ -12 NF thread	5/8
9.	Length of $2\frac{1}{4}$" diameter	$\frac{1}{2}$
10.	Size of center drill hole	3/32
11.	Number of threads per inch on $1\frac{1}{4}$" diameter	12
12.	Minimum limit on $1\frac{1}{4}$" diameter	1.249
13.	Angle tolerance	$\pm \frac{1}{4}^{o}$
14.	Symbol for finished surface	✓
15.	Finish required on unspecified surfaces	125
16.	Heat treat hardness specified	38 - 42 R/C
17.	Number of parts required	2
18.	Maximum allowable length of part	6 29/64
19.	Size of thread relief	3/32
20.	Size of fillet	1/8 R



MAT'L: 4140 H.R.S. - 2 REQ'D
H.T. 38-42 R/C

TOLERANCES UNLESS OTHERWISE NOTED		SPINDLE SHAFT	
FRACTIONS	± 1/64		
DECIMALS	± .005		
ANGLES	± 1/4°	DWN. BY	DATE:
FINISHES	125	CKD. BY	SCALE:

DWG. NO.
SHT. OF

101

ASSIGNMENT SHEET
ON
ABBREVIATIONS, NOTES, AND SYMBOLS

II-B-3a(AS)
Key

NAME_____ DATE_____

DIRECTIONS: Fill in the blank with that term that will correspond to the given abbreviation, symbol, or note.

EXAMPLE:	1. A.I.S.I.	1. American Institute of Iron and Steel
1.	ANG	1. angle
2.	℄	2. center line
3.	DP	3. dimetral pitch
4.	FPM	4. feet per minute
5.	RMS	5. root mean square
6.	Typ	6. typical
7.	FIR	7. full indicator reading
8.	HSS	8. high speed steel
9.	NTS	9. not to scale
10.	CHAM	10. chamfer
11.	ID	11. inside diameter
12.	TPF	12. taper per foot
13.	F.A.O.	13. finish all over
14.	P	14. pitch
15.	Sym	15. symmetrical
16.	WDF	16. Woodruff
17.	C'Bore	17. counterbore
18.	OD	18. outside diameter

19.	BRO	19.	broach
20.	CDS	20.	cold drawn steel
21.	BC	21.	bolt circle
22.	TOL	22.	tolerance
23.	D	23.	diameter
24.	UNC	24.	Unified National Coarse
25.	C'Sink	25.	countersink
26.	$\sqrt{\perp}$	26.	perpendicular
27.	π	27.	pi
28.	$\sqrt{\text{II}}$	28.	parallel surface lay
29.	ϕ	29.	round bar
30.	$\sqrt{cg}$	30.	60 micro finish

In the following note 3/8 - 16 - UNC - 2A:

31.	3/8	31.	thread diameter
32.	16	32.	threads per inch
33.	UNC	33.	Unified National Coarse thread form
34.	2	34.	class 2 fit
35.	A	35.	external thread

MATCHING TEST
ON
DIMENSIONS, NOTES, AND ABBREVIATIONS

NAME_____ DATE_____

DIRECTIONS: One item from Column I is closely related to or associated with an item in Column II. Place the capital letter of the associated term in Column II in the blank space at the left of the number in Column I.

EXAMPLE: __B__ 1. Non-control finish mark

A. Note
B.
C. Limit

Column I	Column II
__E__ 1. Bolt circle	A. CI
__H__ 2. Brinell hardness number	B. ℄
__I__ 3. π	C. ∠
__M__ 4. Total indicator reading	D. CSTG
__O__ 5. Finish all over	E. BC
__P__ 6. 63✓	F. ⊥
__L__ 7. Class two-external	G. Datum plane
__F__ 8. Lay of surface	H. BH
__T__ 9. Used to measure surface finish	I. 3.1416
__G__ 10. Term for reference edge	J. RMS
__B__ 11. Center line	K. HT TR
__Q__ 12. Permissible variation in size	L. 2A
__S__ 13. Diametral pitch	M. TIR
__R__ 14. Ratio	N. UNF
__A__ 15. Cast iron	O. FAO
__N__ 16. Unified national fine	P. 63 Microinch finish
__C__ 17. Angle	Q. Tolerance
__D__ 18. Casting	R. :
__K__ 19. Heat treat	S. DP
__J__ 20. Root mean square	T. Profilometer
	U. Limit

SIMPLE RECALL TEST
ON
DIMENSIONS, NOTES, AND SYMBOLS

NAME_____ DATE_____

DIRECTIONS: Read each statement carefully. When the answer has been selected which will complete the statement correctly, place the answer in the corresponding blank space in the right hand column.

EXAMPLE: 1. A prism is one type of ____ figure. ___geometric___

1. Holes are located with reference to their ____. ___center lines___
2. Location dimensions ____ surfaces with respect to each other. ___position/locate___
3. The normal tolerance for a fractional dimension is ____. ___$\pm$ 1/64___
4. Angles are measured in ____, minutes and seconds. ___degrees___
5. The note $\frac{1}{2}$ drill - 2 holes - 3/4" deep is classified as a ____ note. ___local___
6. The lower limit of $2.375 \pm .002$ is ____. ___2.373"___
7. A reference edge is commonly referred to as a/an ____. ___datum plane___
8. A dimension giving the diameter of a hole is a ____ dimension. ___size___
9. A drawing whose scale is 1" = 2" is ____ than its actual size. ___smaller___
10. The fractional size of the dimension 3.06" is ____. ___3 1/16"___
11. The largest size an angle whose dimension is given $30^{o} \pm \frac{1}{2}^{o}$ is ____. ___30° 30'___
12. The most common method of representing a thread on a drawing is the ____ method. ___simplified___
13. In the thread note 5/8 - 18 - UNF - 2B, the 18 represents the ____. ___number of threads/in.___
14. The term "____" surface refers to surfaces that have material removed. ___finished___
15. The ____ of a surface finish indicates the direction of the machine tools marks. ___lay___

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

II-B-4(1)

SUBJECT: Principles of Sectional Views

AIM: The student will be able to identify the various types of sectional views; their application; and read and interpret the print as required to produce the required part.

TEACHING AIDS: Transparencies, I. Ed. M-VII-T, Figures 22-30
Information Sheet: II-B-4(IS) "Principles of Sectional Views"
Cutaway models
Sample prints

MATERIALS: Chalkboard
Overhead projector and screen

REFERENCES: Basic Blueprint Reading and Sketching
Blueprint Reading for Metal Working Trainees
Print Reading for Machine Shop
Technical Drawing

PREREQUISITE EXPERIENCE OF THE LEARNER: The student must have read required assignment and have completed previous lessons and assignments.

I. PREPARATION (OF THE LEARNER - MOTIVATION)

In previous lessons we have learned the basic method of representing objects by views and how these views are represented by individual lines that have a specific meaning.

However, frequently parts that are encountered have complicated interior features that cannot be shown clearly by means of hidden lines. In addition, it is difficult to show dimensions of these features adequately.

However, this is accomplished by slicing or cutting through the object much as we would in cutting an orange, apple, or piece of cake and removing it. A cutaway view is then seen of the object. This cutaway is called a sectional view or simply a section.

In this lesson we will study the principles of sectioning, the various types of sectional views, and how to read and interpret sectional prints.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Purpose of Sectional Views	1. A type of auxiliary (helping) view 2. Intended to show interior of an object or part a. Construction; machined surfaces; lines b. Dimensions otherwise difficult to show c. Assembly of integral parts

3. True shape of uniform parts, such as ribs, spokes, and bars
4. Removed sections for enlargement to obtain greater clarity
5. Various types of materials used in an assembly

B. Principle of Sectional Views

1. Object is cut by an imaginary plane referred to as the cutting plane
   a. Cut as though slicing an apple and removing a part
   b. Slice or cut is the cutting plane
   c. Part remaining is the section view
2. Cutting plane line is shown in a principal view
3. Direction that a section is viewed is indicated by arrows
   a. Arrows point in direction of sight
   b. Normally at each end of cutting plane line
   c. Cutting plane may vary some with different types of sections
      (1) Bent or offset
      (2) Circular arc
      (3) Conventional break line
4. Section is identified and labeled by letters at end of arrows
5. Material cut in a sectioned view is shown by cross-hatching (section lining)
6. Type of material is indicated by the arrangement or pattern of cross hatch

   Note: Cast iron is the general sectioning symbol

Show: Transparency Figure 22

C. Types of Sections

1. Consist of four (4) major types of sectional views
   a. Full section
   b. Half section
   c. Broken out section
   d. Revolved section
2. Type used is based on information to be conveyed and design of the object

1. Full section

1. Cutting plane passes entirely through and across the object

   Note: The part is cut in half

Show: Transparency
Figure 23

2. Cutting plane may pass straight through or be offset
   Note: Offset of cutting plane to pass through features otherwise excluded
   Note: An offset section would be an example
3. Arrows are shown at both ends
   Note: Labeling of cutting plane is optional unless more than one sectional view is shown

2. Half Section

1. Cutting plane passes halfway through the object
   Note: Two cutting planes pass at right angles to each other along center lines or symmetrical axis

Show: Transparency
Figure 24

2. One-quarter of the object is removed
   Note: In sectioned view one-half of the object is shown sectioned
3. Limited primarily to symmetrical objects
4. Shows both internal and external parts without the use of hidden lines
5. Center line separates the sectioned and non-sectioned portions of the view
   Note: No edge exists on the object at the center

3. Broken Out Section

1. Used to expose only a small interior section
   Note: Use of a full or half section would remove some feature that must be included
   Example: A keyway

Show: Transparency
Figure 25

2. Cutting plane extends only slightly beyond features shown in section
3. Standard short break line represents the cutting plane
   Note: Cutting plane is not shown in adjacent or principal view

4. Revolved Section

1. Sectional view is shown by rotating or turning the view to reveal true shape
2. View is achieved by turning cutting plane 90^{o} on its axis
   Note: Plane is assumed perpendicular to the center line or axis of the object

Show: Transparency
Figure 26

3. Visible lines adjacent to a revolved section may be broken out
4. Section view may be superimposed
5. Shows cross section of bar, arm, spoke, or other elongated parts

5. Additional Sectioning Techniques

Show: Transparency Figure 27

1. Removed sections - type of revolved section
   a. Removed completely from main view
   b. Each section is labeled
   Example: Section A-A, Section B-B, etc.
   Note: Letters correspond to letters at ends of cutting plane line
   c. Used to show gradual change in a part or one that is not uniform in shape
   Note: May require more than one removed sectional view
   d. Removed section may be drawn larger to improve clarity and for dimensioning

Show: Transparency Figure 28

2. Offset section
   a. Type of full section
   b. Cutting plane line is broken, bent, or offset
   c. Reveals interior details which are not in a straight line
   d. Offset or bent line of cutting plane is not shown in sectioned view
   e. Some views may require use of hidden lines to improve clarity
   f. May require more than one sectional view

Show: Transparency Figure 29

3. Aligned sections
   a. Type of full section
   b. Cutting plane is bent to include certain angled elements
   c. Cutting plane is revolved into the original plane
   d. Sectional view reveals part as it would be seen in revolved position; that is, the "aligned position"

Show: Transparency Figure 30

4. Partial section
   a. Saves drafting time and space
   b. Shows only those features required for minimum representation
   c. Shows only the portion that would otherwise be hidden

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION).

1. Have students identify the various types of sectional views.
2. Ask oral questions concerning use or application of each sectional view.

3. Discuss represented features shown in the sectional view.
4. Show examples of cutaways of machined parts.
5. Students read and interpret prints with sectional views.
6. Students complete assignment sheets on print reading.

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENTS' COMPREHENSION OF MATERIALS PRESENTED).

Simple Recall

1. A sectional view of a symmetrical object with one-fourth imagined removed is called a/an half section.
2. The resulting view whereby a cutting plane passes completely through an object is known as a/an full section.
3. The arrowheads on a cutting plane line show the direction of sight of the viewer.
4. A section whereby both the interior and exterior of an object are shown in one view without hidden lines is referred to as a/an half section.
5. The material symbol for cast iron is normally used for all section lining.
6. The identification of sectional views are made by letters labeled at the ends of the cutting plane arrow.
7. To expose or show only a small section of a part, the broken out section would be used.
8. To improve the clarity of a small section or for the prupose of dimensioning, the section is shown in a removed section.
9. A/an aligned section is used to show an angled element in the original plane.
10. Crossections of ribs, spokes, and bars are shown by a/an revolved section.

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT).

1. The purpose of a sectional view is to:
    1. Show complicated interior parts
    2. Provide means for clarity in dimensioning small interior features
    3. Show the assembly of integral parts
    4. Show true shape of parts such as ribs, spokes, webs, and bars
    5. Remove section for enlargement and greater clarity
    6. Show different types of materials in an assembly

2. The principle of sectioning consists of:

    1. An imaginary cutting plane cutting through the object
    2. Part of the object is removed
    3. Part remaining is exposed showing the interior features
    4. Solid features of the interior are cross-hatched
    5. Holes or voids, bolts, ribs, webs, etc. are not shown sectioned to avoid misrepresentation

3. There are four (4) main types of sections:

    1. Full section
    2. Half section
    3. Broken out section
    4. Revolved section

4. Additional sectional techniques used are:

    1. Removed sections
    2. Offset sections
    3. Aligned sections
    4. Partial sections

SUGGESTED READING FOR STUDENT:

II-B-5(IS), "Principles of Auxiliary Views"

The Next Lesson Is: II-B-5(I) "Principles of Auxiliary Views"

107

INFORMATION SHEET
ON
PRINT READING

II-B-4(IS)

SUBJECT: Sectional Views

INTRODUCTORY INFORMATION:

Frequently the interior of an object is so complicated that the customary method of showing hidden features with dashed lines is confusing and almost impossible to read. In cases such as this, and where parts are shown in assembly or where some detail of the shape of the object is not clear, an auxiliary (helping) view is used. This auxiliary view is called a sectional view. Sectioned views assist in the clarification of: interior parts; assembly of different parts or materials; description of irregular shapes; and dimensioning purposes.

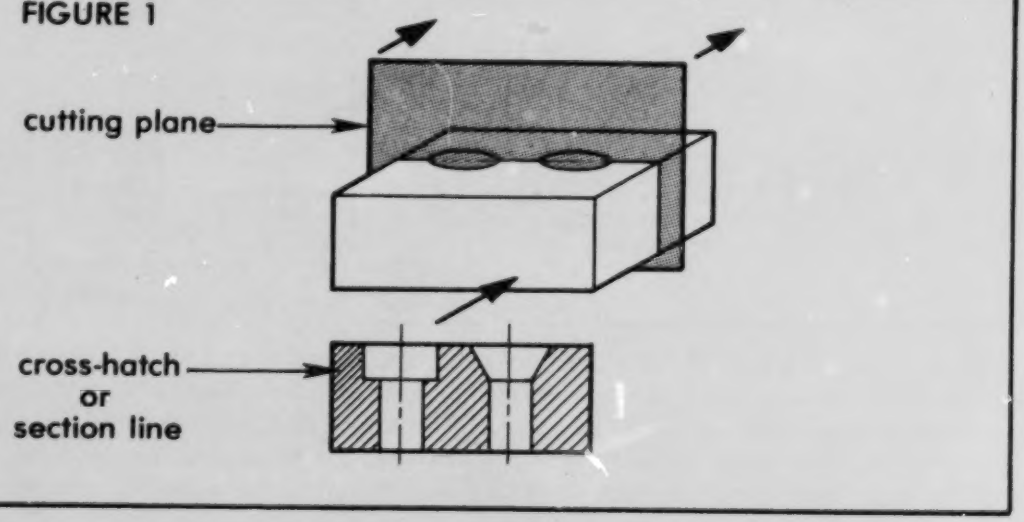
Understanding the principles of sectioning and of the various types is vital to the worker's ability to read and interpret prints that are common to the machinist.

GENERAL INFORMATION

Principle of Sectioning

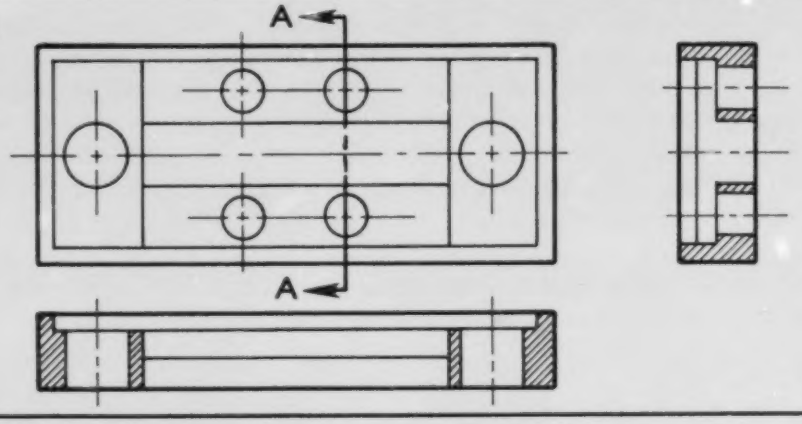
In sectioning, the object is cut by an imaginary plane called the cutting plane, which cuts the object in two, in much the same manner as cutting into an apple and removing a portion. A view of the cutaway part is drawn showing portions of the object that are solid and those that are voids or spaces. The solids are shown by section lining or "cross-hatching" and the spaces or voids are left blank. All edges exposed are shown as visible edges, as in Figure 1.

FIGURE 1



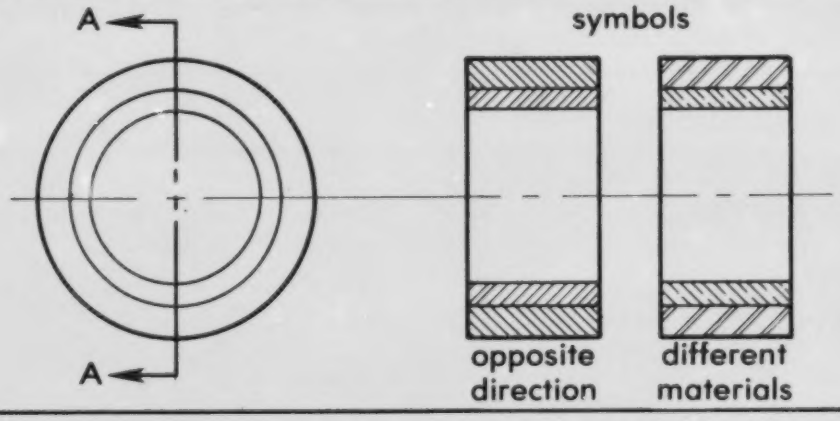
The place from which the section is taken must be identifiable on the drawing in a principal view, and the solids and voids must be distinguished on the sectional view. In many cases the place from which the section is taken is obvious and a cutting plane is not required. Such is the case where sections are quite evidently taken through the center as indicated by the center line. If the place from which the section is taken is not obvious, then the cutting plane with directional arrows and identification letters are shown, as in Figure 2. The cutting plane A-A is shown because the section might be taken elsewhere.

FIGURE 2



The solids of the section are section lined or "cross-hatched" using the material symbol for cast iron which is used in all cases except where the type of material is to be shown or where two or more parts show in assembly, in which case the symbol for each material is shown or the direction of section lines are drawn in opposite directions. These two methods are illustrated in Figure 3.

FIGURE 3



Although there are different types of sections, and the sectional views have been named for identification and specifying the type of view required in a drawing, the names are not shown on the drawing as the views are easily interpreted and the worker does not require the name to read the drawing. The sectional names are assigned by the character of the section or the amount of the view in section, and based upon the information to be conveyed and design of the object.

Although there are many techniques in sectioning there are four major types; namely: full section, half section, revolved section, and broken out section. From these basic four, additional techniques are used for specific sectioning purposes.

Full Section

The full section is one in which the cutting plane passes entirely across the object cutting it into two pieces, as in Figure 4. The full section cutting plane line does

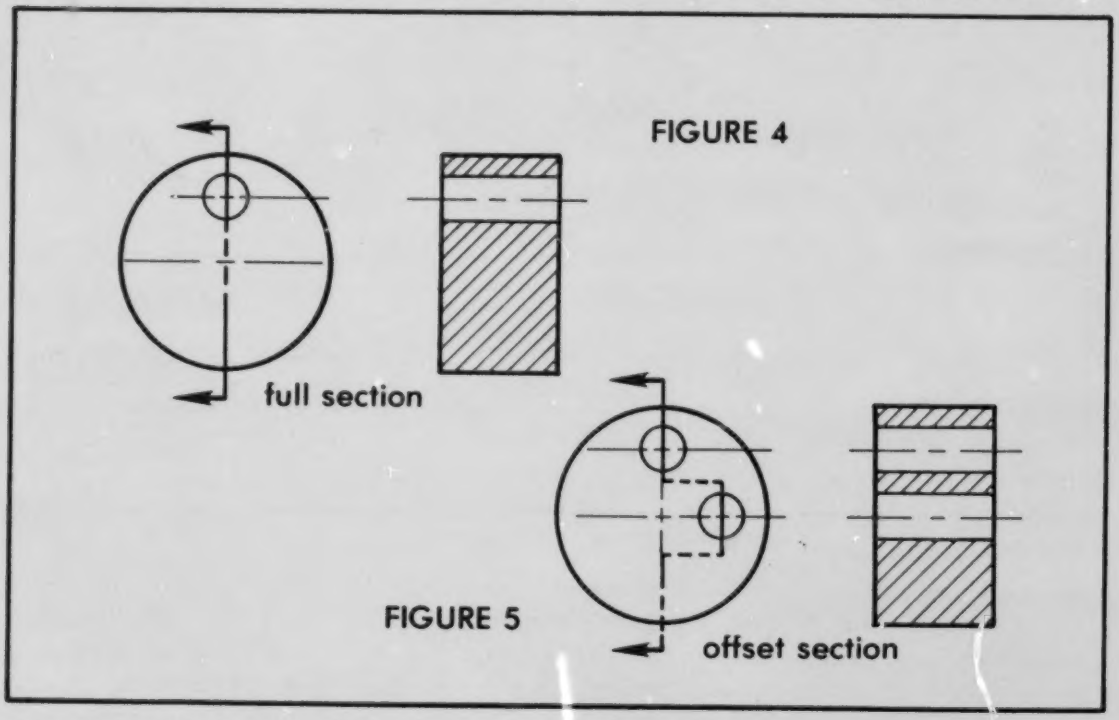


FIGURE 4

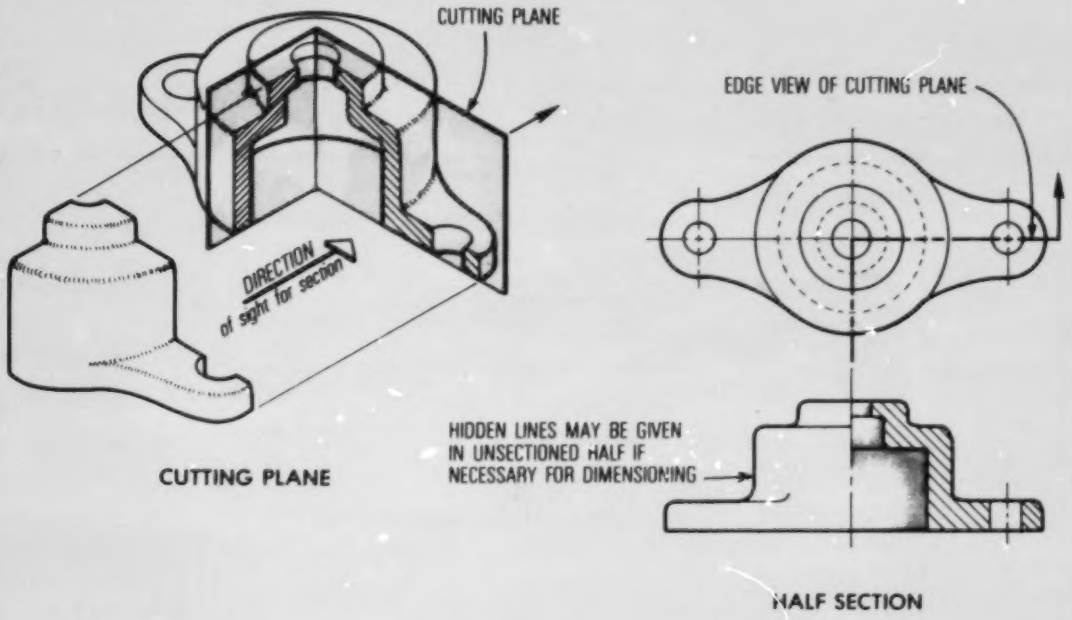
FIGURE 5

not necessarily have to follow one direction only. In sectioning through irregular objects it may be desirable to include features that do not lie in a straight line. By bending or "offsetting" the cutting plane, as in Figure 5, the cutting plane picks up both holes. This type of full section is called an offset section. The cutting plane line of an offset section always changes direction at right angles but is not shown in the sectional view.

Half Sections

On parts that are symmetrical, interior details can be fully described by passing the cutting plane only halfway through the object, thereby removing only one-fourth of the object. The result is a half section, Figure 6. A half section has the advantage of exposing the interior of one-half the object and retaining the exterior of the other half. The greatest usefulness of the half section is in assembly drawing, in which it is often necessary to show both internal and external construction on the same view without dimensions. In half section drawings, a center line is used to separate the sectioned half from the unsectioned half, although a visible line may be used.

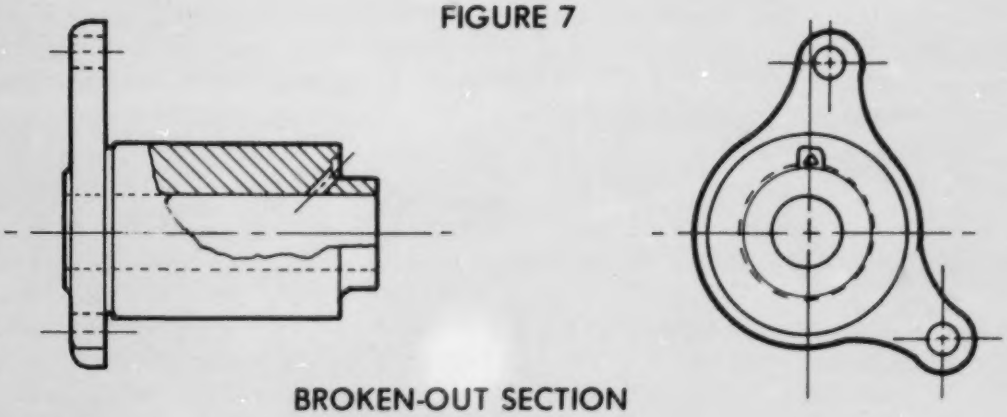
FIGURE 6


CUTTING PLANE
EDGE VIEW OF CUTTING PLANE
DIRECTION of sight for section
CUTTING PLANE
HIDDEN LINES MAY BE GIVEN IN UNSECTIONED HALF IF NECESSARY FOR DIMENSIONING
HALF SECTION

Broken-Out Section

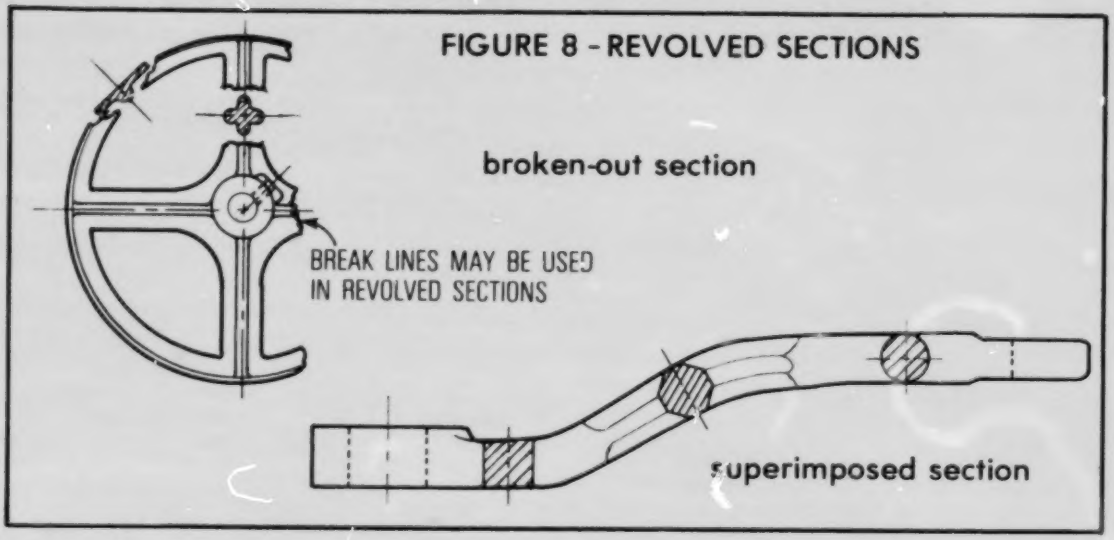
Often an interior portion must be shown, but to use a half section or full section would remove some feature that must be included. When this is the case, a partial section called a broken-out section it is assumed that the cutting plane passes through the feature even though the cutting plane is not drawn. A freehand break line is used instead and limits the sectioned area.

FIGURE 7



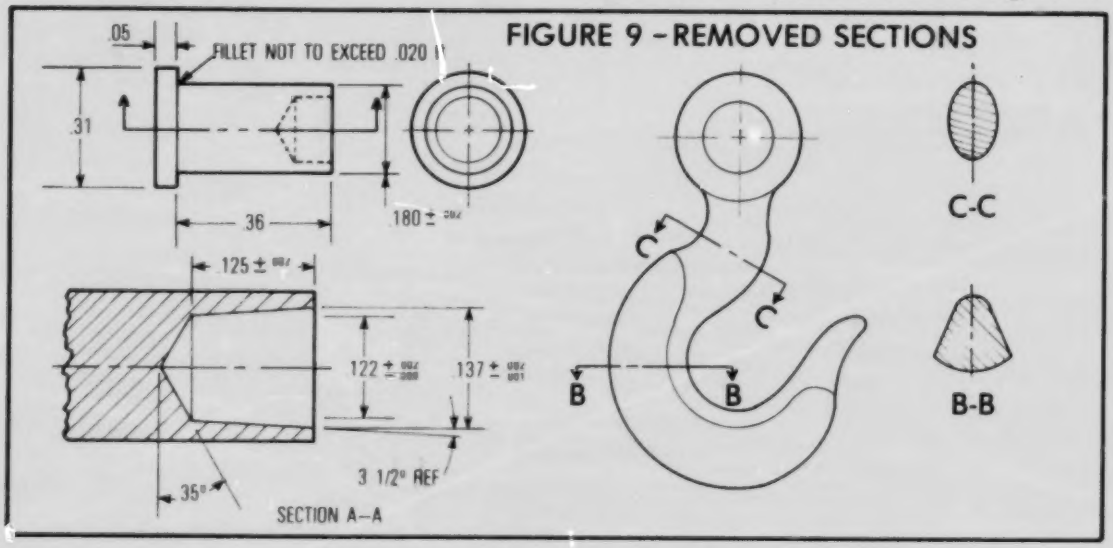
Revolved Section

A revolved section is used to describe the cross section of an object, such as a spoke, rib, bar, or other detail at a special point. Such sections are made by assuming a plane perpendicular to the center line or axis of the bar or other object, then revolving the plane through 90° about the center line at right angles to the axis. The visible lines adjacent to the revolved section may be "broken-out" or the superimposition of the revolved section on the original drawing, as in Figure 8.



Removed Section

Frequently, as a means of clarifying the shape of an object or showing dimensions more clearly, a section may be removed from its normal position, as in Figure 9.



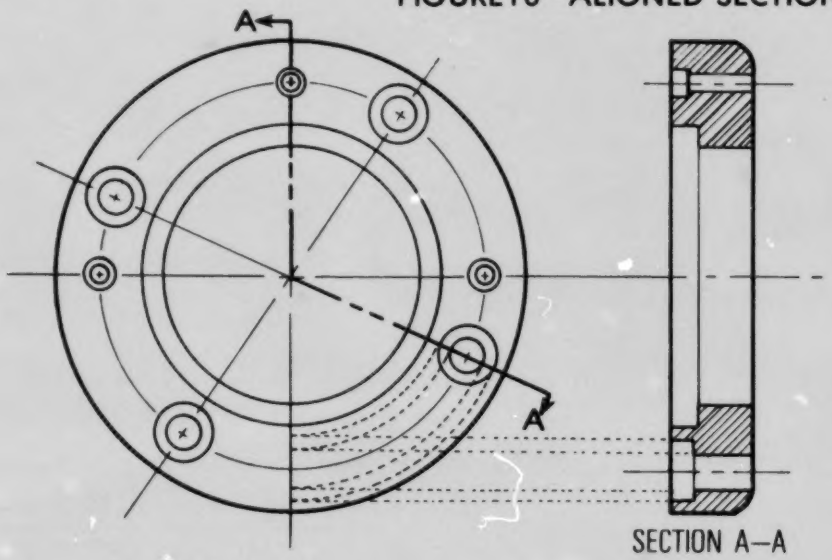
Removed sections are labeled to correspond to the letters at the end of the cutting plane line, such as section A-A, B-B, and C-C. In some cases it may be necessary

to show a removed section on another sheet. In these cases a cross-reference is given, such as: Section B-B on sheet 2.

Aligned Sections (angular sections)

The aligned section is a type of full section, whereby the cutting plane line is bent to include certain elements, such as holes that are not located on either the vertical or horizontal axis, and revolves these elements onto a vertical position (aligned), from where it is projected to the sectional view, as in Figure 10. By aligning the hole, the sectional view gives a clearer and more complete description than if it were projected in its true position.

FIGURE10 - ALIGNED SECTION



ASSIGNMENT SHEET
ON
SECTIONING

II-B-4(AS)

SUBJECT: Complete Sectional View

AIM: The student will be able to complete the sectional view of a given object with the specified material symbol and identify the type of sectional view.

INTRODUCTORY INFORMATION: Frequently the machinist is exposed to drawings that have complicated interior parts that require a more clear method of describing the interior. By using a sectioned view, the interior or a special section of the drawing is exposed so as to view the interior more clearly. Information contained in this assignment will provide the student with the knowledge required to read and interpret a sectioned view, to visualize the interior of an object, and to properly section the part with the required material symbol.

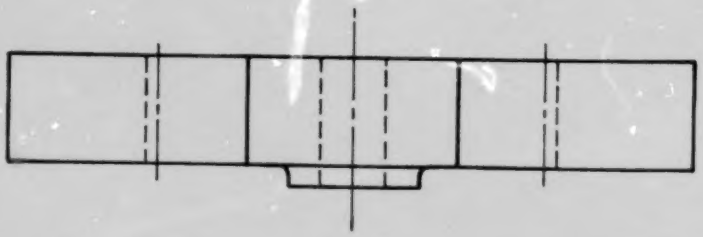
REFERENCE: Information Sheet II-B-4(IS) "Sectional Views"

QUESTIONS OR PROBLEMS: Assignment Sheet II-B-4(AS) consists of six problems. Each problem is a multi-view drawing with a cutting plane shown in one view. The student is to complete each drawing by completing the sectioned view with the necessary lines and by sectioning lining the view with the specified material symbol.

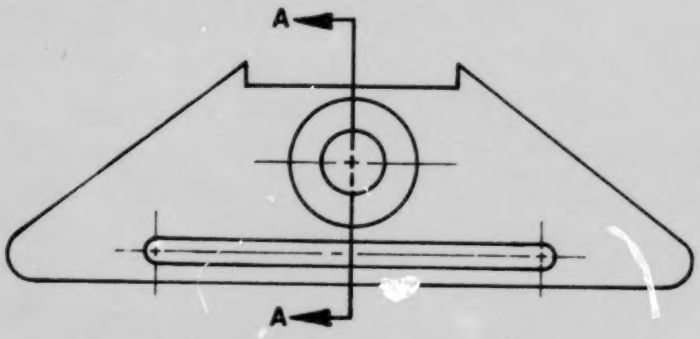
Name:_____

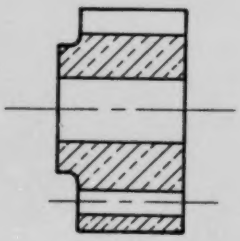
SECTIONING EXERCISE #1

II-B-4(AS)
Date:_____

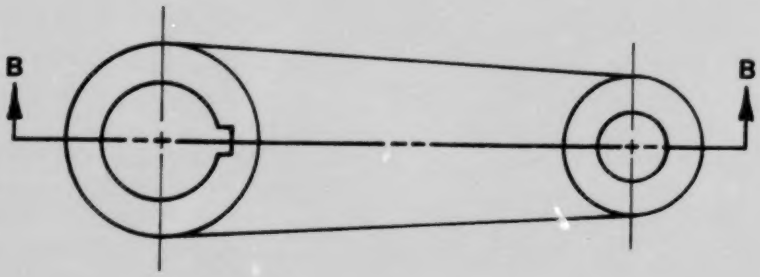


MAT'L: BRASS

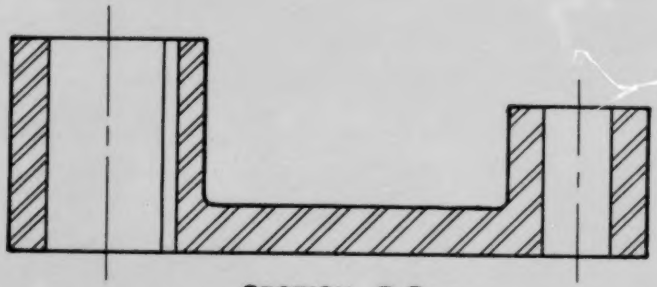




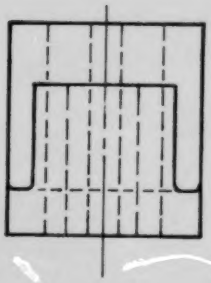
SECTION A-A



MAT'L: STEEL



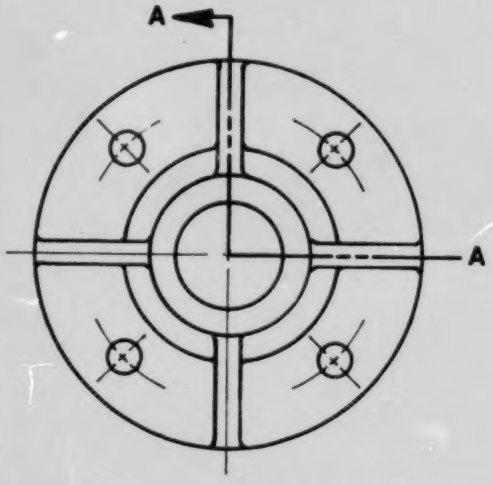
SECTION B-B



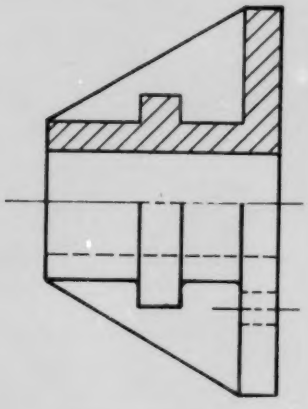
Name:_____

SECTIONING EXERCISE #2

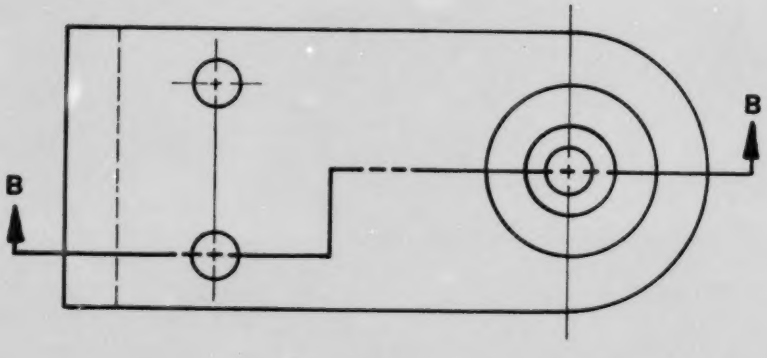
II-B-4(AS)
Date:_____



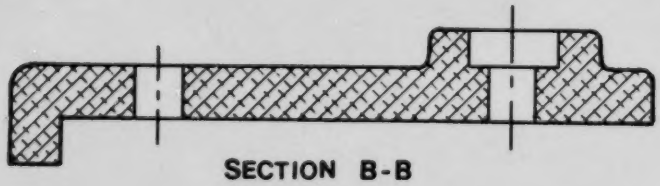
MAT'L: CAST IRON



SECTION A-A



MAT'L: ALUMINUM

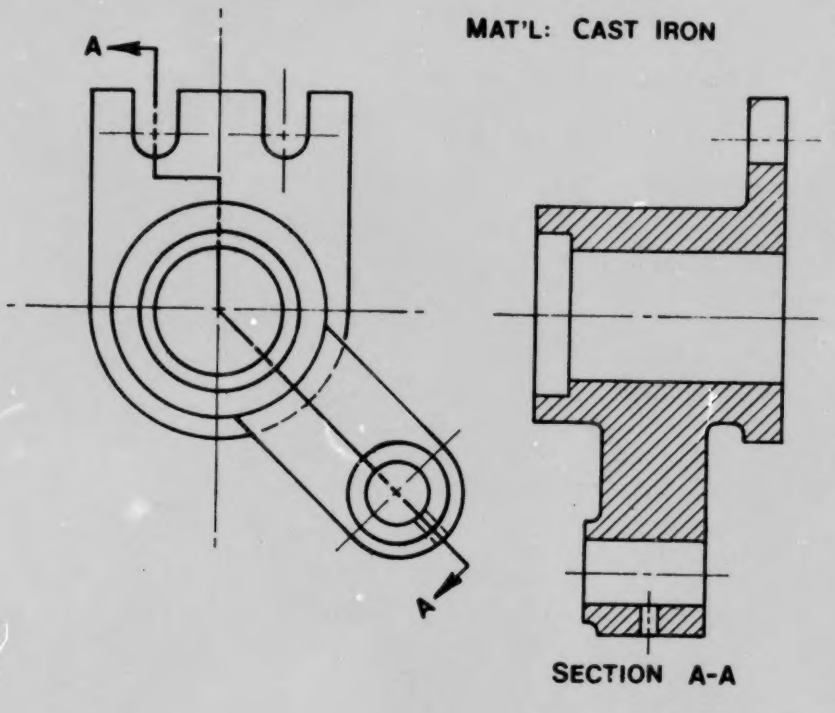


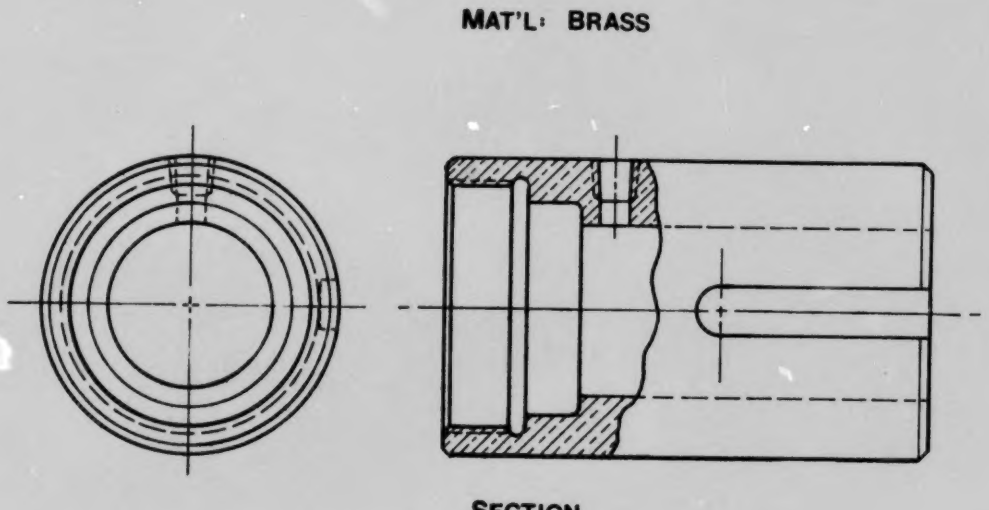
SECTION B-B

Name:_____

SECTIONING EXERCISE #3

II-B-4(AS)
Date:_____





ASSIGNMENT SHEET
ON
SECTIONING

II-B-4a(AS)

SUBJECT: Read A Sectioned Print

AIM: The student will be able to read and interpret a sectioned print by studying the print and recording specific information required in the manufacturing of the part.

INTRODUCTORY INFORMATION: One of the valuable functions of sectioning is to provide a clear method of dimensioning internal parts. The practice of dimensioning to hidden lines creates confusion in relating the dimension to the part that is dimensioned. The clearer that a dimensioned part can be shown, the easier it is for the machinist to interpret the drawing and locate each dimension. This reduces the time lost in trying to interpret the drawing, thereby reducing manufacturing cost. This assignment will assist the student in the reading of prints more quickly and accurately.

REFERENCE: Information Sheet II-B-4(IS) "Sectional Views"

QUESTIONS OR PROBLEMS: In Assignment Sheet II-B-4a(AS) the student will carefully study the print and record the correct answer in the blank corresponding to the given term or statement.

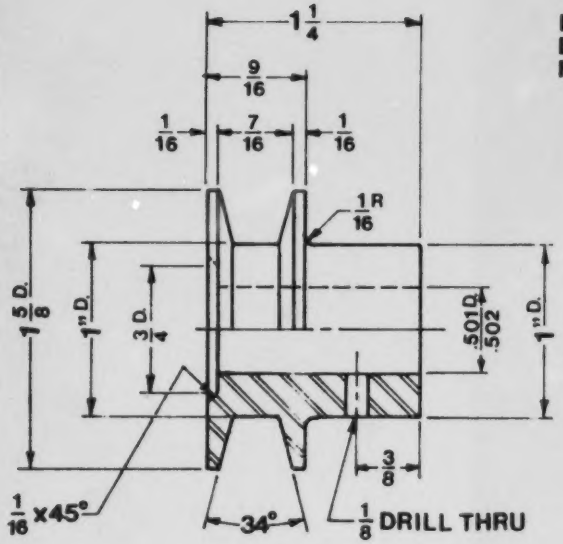
ASSIGNMENT SHEET
ON
SECTIONING

II-B-4a(AS)
key
#1

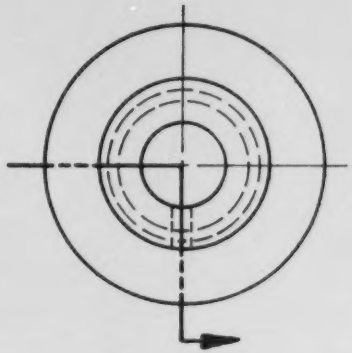
NAME_____ DATE_____

DIRECTIONS: Read and interpret the following print by recording the correct answer in the blank corresponding to the statement.

EXAMPLE:	1. Print Number	C-171
1.	Material	4140 H. R. S.
2.	Largest pulley diameter	1 41/64
3.	Oil hole size	1/8
4.	Maximum shaft hole size	.502
5.	Smallest pulley diameter	1
6.	Vee groove angle	34^{o}
7.	Oil hole location from end of hub	3/8
8.	Fillet size between pulley and hub	1/16
9.	Type section	half section
10.	Pulley shaft diameter	$\frac{1}{2}$ (.500)
11.	Vee groove greatest width	7/16
12.	Length of hub	11/16
13.	Depth of pulley recess	1/16
14.	Pulley recess diameter	3/4
15.	Maximum allowable groove angle	$34^{o}15'$
16.	Name of part	V Belt pulley
17.	Minimum shaft hole size	.501
18.	Fractional dimension limits	$\pm$ 1/64
19.	Treatment of edges	break all edges
20.	Pulley width	9/16



NOTE:
BREAK ALL SHARP EDGES
FINISH ALL OVER



MAT'L: 4140 H.R.S.
H.T. 38-42 R/C

TOLERANCES UNLESS OTHERWISE NOTED	SCHOOL OR COMPANY ADDRESS CITY, STATE		
FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES + 1/4° FINISHES 125√	V BELT PULLEY		
	DWN. BY	DATE	DWG. NO. C-171
	CKD. BY	SCALE	SHT. OF

ASSIGNMENT SHEET
ON
SECTIONING

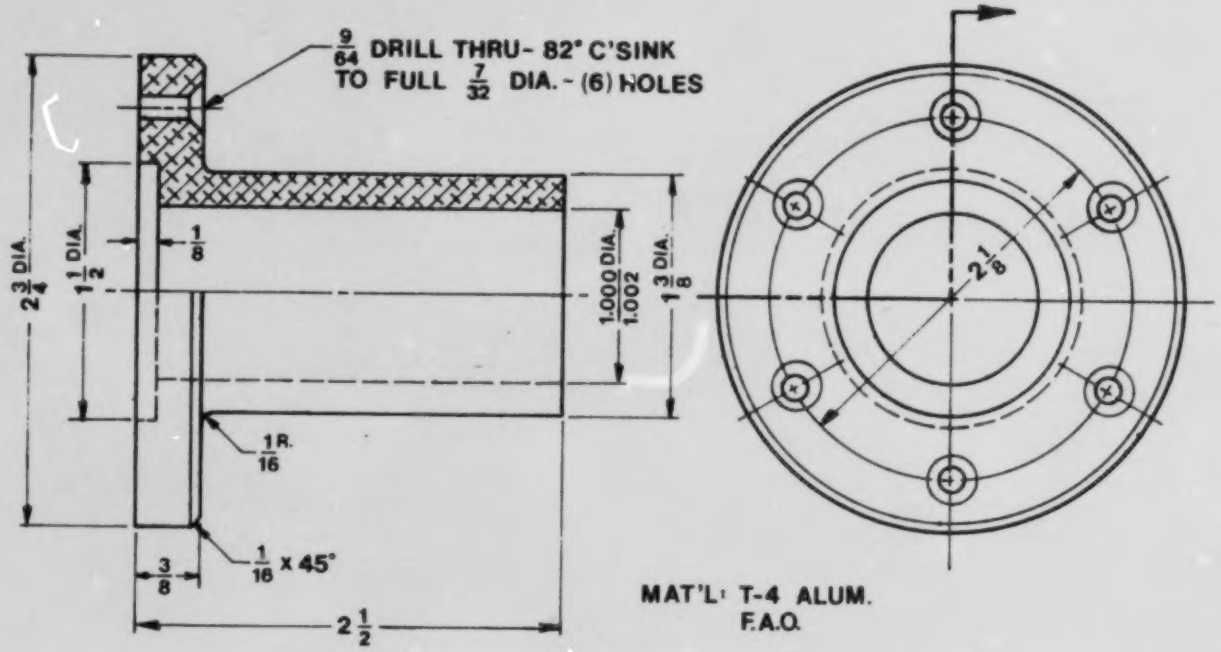
II-B-4a(AS)
key
#2

NAME_____ DATE_____

DIRECTIONS: Read and interpret the following print by recording the correct answer in the blank corresponding to the statement.

EXAMPLE: 1. Print Number — C-111

1.	Part name	cam carrier support
2.	Minimum bore diameter	1.000
3.	Material	T-4 Aluminum
4.	Bolt circle diameter	2 1/8
5.	Diameter of counter bore	1 1/2
6.	Hub length	2 1/8
7.	Type finish specified	125
8.	Outside diameter of hub	1 3/8
9.	Largest diameter (flange)	2 3/4
10.	Angle spacing of holes	60^{o}
11.	Depth of counter bore	1/8
12.	Flange thickness	3/8
13.	Fraction tolerance permitted	$\pm$ 1/64
14.	Decimal tolerance permitted	$\pm$ .005
15.	Largest bore diameter	1.002
16.	Number of drilled holes	6
17.	Type section	half section
18.	Radius between hub and flange	1/16
19.	Size flange chamfer	1/16 x 45^{o}
20.	Operations performed on screw holes	9/64 drill; C'SK 82^{o} to 7/32 full diameter



MAT'L: T-4 ALUM.
F.A.Q.

TOLERANCES UNLESS OTHERWISE NOTED	SCHOOL OR COMPANY ADDRESS CITY, STATE
FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES + 1/4° FINISHES 125	CAM CARRIER SUPPORT
DWN. BY / DATE	DWG. NO. C-111
CKD. BY / SCALE	SHT. OF

SIMPLE RECALL ON SECTIONAL VIEWS

NAME_____ DATE_____

DIRECTIONS: Read each statement carefully. When the answer has been selected which will complete the statement correctly, place the answer in the corresponding blank space in the right hand column.

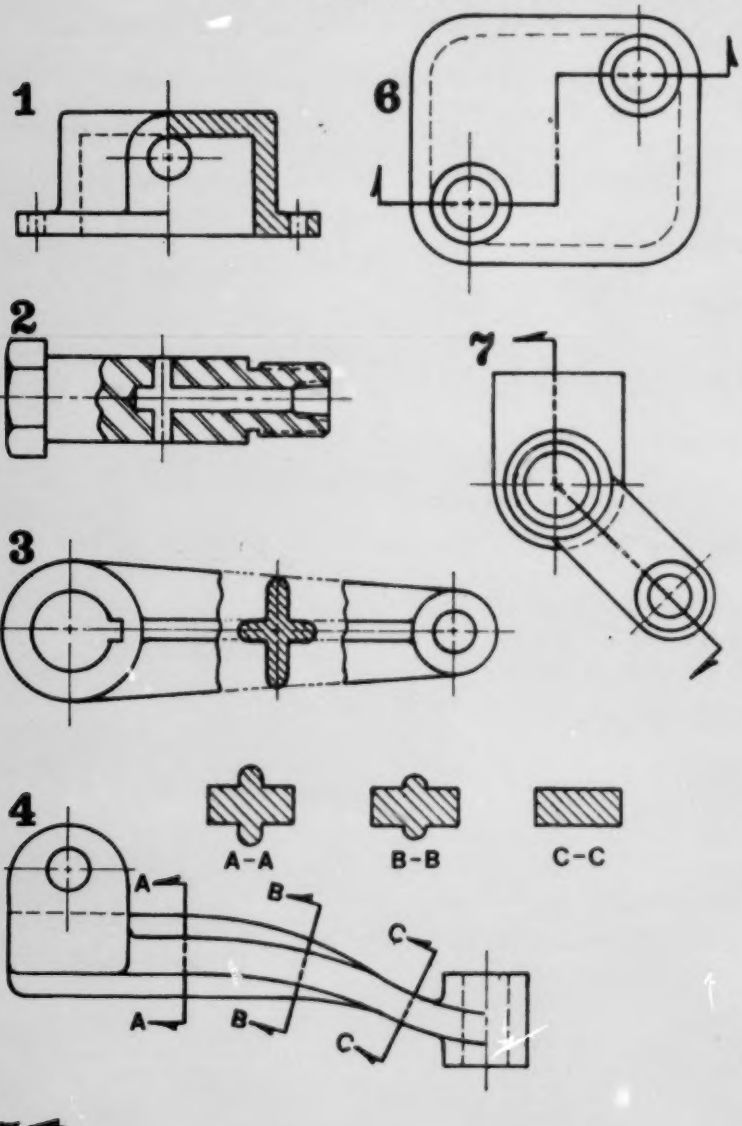
EXAMPLE: 1. The symbol for general use of all material is ____. cast iron

1. Half sections are commonly used for objects that are ____ in shape. symmetrical
2. In a ____ section the cutting plane is assumed perpendicular to the center or axis of the object and rotated 90°. revolved
3. The arrowheads on a cutting plane line give the direction of ____ of the viewer. sight
4. The removed section of an object is identified by ____. letters
5. On broken-out sections, the limits of the section are shown by a ____ line. short break
6. In a sectional view, solid portions of the object cut by the cutting plane are section lined or ____. cross-hatched
7. In an assembly section the section lines may show different types of ____ or drawn in opposite directions. material
8. To show features that do not lie in a straight line, the cutting plane is bent at 90° angles to form a/an ____ section. offset
9. A ____ section is used to dimension parts that are too small to do so on the original drawing. removed
10. Holes on a flange that do not lie on either the vertical or horizontal axis are shown by use of a/an ____ section. aligned

PICTORIAL RECALL TEST
ON
SECTIONAL VIEWS .

NAME_____ DATE_____

DIRECTIONS: Below are different types of sectional views or procedures and sectioning symbols. Identify each and write the answer in the corresponding numbered blank space provided for in the right hand column.



1. Half Section
2. Broken-out Section
3. Revolved Section
4. Removed Section
5. Full Section
6. Offset Section
7. Aligned Section
8. Cutting Plane Line
9. Steel
10. Cast Iron

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

II-B-5(I)

SUBJECT:	Principles of Auxiliary Views
AIM:	The student will understand the principles and application of auxiliary views; identify the classification and types of auxiliary views; and read and interpret prints as required to machine a given part.
TEACHING AIDS:	Transparencies, I. Ed. M-VIII-T, Figures 31-34 Information sheet II-B-5(IS) "Principles of Auxiliary Views" Sample prints Model or sample part
MATERIALS:	Chalkboard Overhead projector
REFERENCES:	Basic Blueprint Reading and Sketching Print Reading for Machine Shop Technical Drawing
PREREQUISITE EXPERIENCE OF THE LEARNER:	Student must have completed previous assignment and read the required information sheet, II-B-5(IS) "Principles of Auxiliary Views"

I. PREPARATION (OF THE LEARNER-MOTIVATION)

Many parts have surfaces that are not parallel with the regular planes of projection. These surfaces cannot be accurately shown or dimensioned by conventional means. Therefore, a special helping view is required to present the surface. This special view is referred to as an auxiliary view. The word auxiliary is derived from the Greek word auxein, meaning to increase or help.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Auxiliary Views Show sample part or model	1. A special type of orthographic view 2. A projection of a surface not parallel with a regular plane of projectinn Example: Inclined/sloping or oblique surface a. An inclined surface is perpendicular to only one regular plane of projection b. Oblique or skewed surface is inclined to all regular planes of projection 3. Auxiliary "Plane of Projection" is parallel to inclined surface
Show: Transparency Figure 31,32	

Note: Edge view of the surface

4. Projectors emanate vertically from inclined surface, piercing plane at right angle
5. Produces true image of inclined surface
6. In proper relation when auxiliary plane is hinged at intersection of frontal plane and swung at flush with frontal plane
7. Auxiliary view projected from regular view is a primary auxiliary view
8. Auxiliary view projected from the primary view is a secondary auxiliary view

   Note: Required for oblique surfaces and will be discussed later

B. Classification of Views

   Show: Transparency Figure 33

1. According to principal dimension in the auxiliary view
   a. Height auxiliary
   b. Depth auxiliary
   c. Width auxiliary
2. Position auxiliary view assumes when projected from principal view
   a. Front view projection
   b. Top view projection
   c. Side view projection

C. Purpose

1. Describe clearly the shape and size of inclined or oblique surfaces
2. Show true length of an edge
3. Show true size of angles, circles, or irregular shapes
4. For dimensioning purposes

   Note: Surfaces, angles, lines must appear in true size to be properly dimensioned
5. Provide clarity by eliminating hidden lines and unnecessary views

   Note: Full auxiliary views are normally not used

D. Types

   Show: Transparency Figure 34

1. Full Auxiliary View - projection of entire part

   Note: Normally not used since projection of normal views would show foreshortened
2. Partial Auxiliary View - used to show details of only one part

   Note: Most commonly used

3. Half Auxiliary View - shows only one-half of symmetrical objects
4. Auxiliary Sections - an auxiliary view shown in section
   a. Entire object behind cutting plane may be shown
   b. Cut surface alone may be shown

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION).

1. Have students identify the various types of auxiliary views.
2. Discuss represented features shown in the auxiliary view.
3. Students read and interpret prints that include auxiliary views.
4. Students complete assignment sheets.

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENTS' COMPREHENSION OF MATERIALS PRESENTED).

True-False

1. An auxiliary view is a projection of a surface that is not parallel to a regular plane of projection. T
2. An oblique surface is inclined to two regular planes and perpendicular to the third plane. F
3. Full auxiliary views are the most frequently used view. F
4. The dimension of an inclined surface is found in the primary auxiliary view. T
5. The use of hidden lines in an auxiliary view is important to the clarity of the object. F
6. Symmetrical parts are commonly shown by a half auxiliary view. T
7. Auxiliary views of ribs or webs are viewed as sectional view. T
8. A partial auxiliary view shows the detail of one part of an object. T
9. Secondary auxiliary views are projected from a regular view. F
10. The function of an auxiliary view is to provide true shape and size description and to properly dimension inclined and oblique surfaces. T

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT).

The true shape of a surface not parallel to a regular plane can be represented only by an auxiliary view, which is projected from the edge view of the surface. The auxiliary plane is assumed hinged to a principal plane and is swung flush with that plane, revealing the auxiliary view and true image of the surface.

The most common surfaces that auxiliary views apply to are: (1) inclined surfaces and (2) oblique surfaces. Inclined surfaces are viewed in a primary auxiliary view, whereas a secondary auxiliary view is required for oblique surfaces.

The purpose in an auxiliary view is to:

1. Show true shape and size of surfaces, lines, circles
2. Provide clarity to drawing
3. Provide for dimensioning purposes

Auxiliary views may be projected as:

1. Full views
2. Partial views
3. Half views
4. Sectional views

Auxiliary views are classified according to:

1. Principal dimension shown in the auxiliary view
2. Position assumed when projected from a principal view

SUGGESTED READING FOR THE STUDENT:

II-C-1(IS) "Sketching Materials and Techniques"
II-C-1a(IS) "Proportion and Making an Orthographic Sketch"

The Next Lesson Is: II-C-1(I) "Orthographic Sketching"

SUBJECT: Auxiliary Views

INTRODUCTORY INFORMATION:

The word auxiliary derives from the Greek word auxein, which means to increase or help. In drawing the function of an auxiliary view is to provide assistance by helping to increase the clarity of a complicated drawing.

Many parts have surfaces that are not parallel with the regular planes of projection, thereby causing the surface to be view distorted. This makes reading and interpretation difficult, as the surface cannot be viewed accurately or dimensioned by conventional methods.

GENERAL INFORMATION

Principle of Auxiliary Views

As previously stated, some objects have slanted surfaces which cannot be clearly shown by means of conventional views. These slanted surfaces may be either inclined or oblique. An inclined surface is one that is at an angle with two regular planes of projection, but is perpendicular to the third. As in Figure 1, surface ABCD is viewed foreshortened (FS) in the top and right side views. In the front view, the surface is perpendicular to the frontal plane and seen as a true length edge (TL). To view the surface in true shape, a special view known as an auxiliary view is needed. This view is one that simply shows the outline of the surface as it appears to the observer when looking directly at the surface, as in Figure 2.

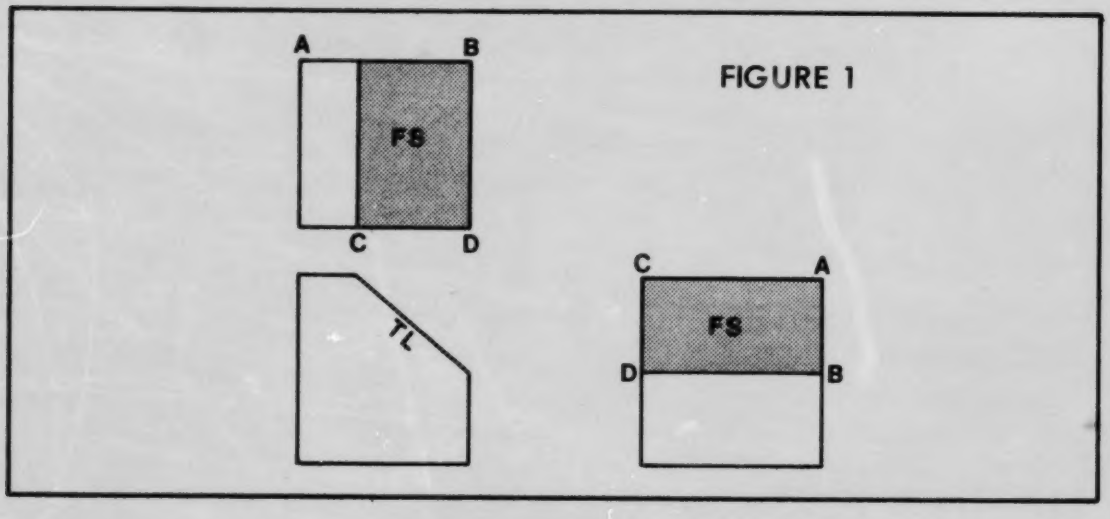


FIGURE 1

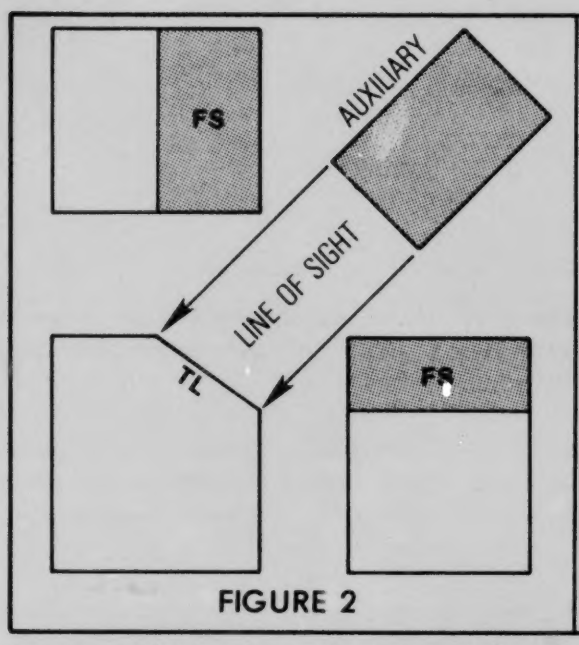


FIGURE 2

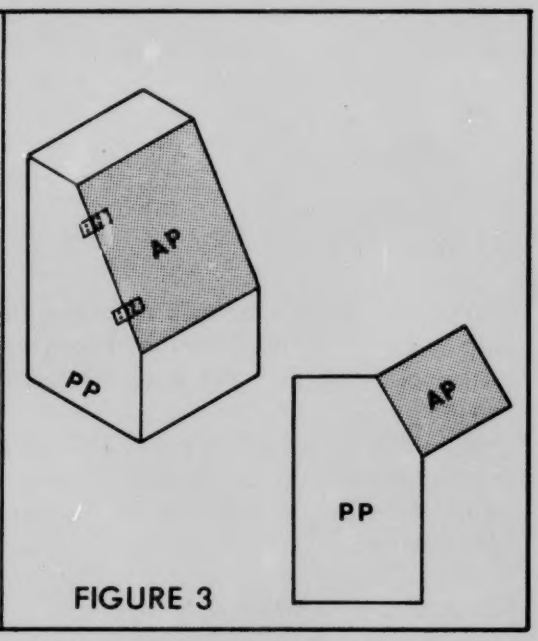


FIGURE 3

In an auxiliary view it is assumed that the slanted surface is hinged to one of the principal planes (PP) and when revolved flush with the principal plane it becomes parallel to the slanted edge, as in Figure 3, thereby showing the surface in true shape. This auxiliary view is referred to as a Primary Auxiliary View.

The oblique (skewed) surface is inclined to all regular planes of projection, and therefore is viewed as a foreshortened (FS) edge in all regular views, as surface ABC is in Figure 4. These surfaces are in such a position that they cannot be shown in true size by projecting them upon normal planes or primary auxiliary planes. In cases such as this, a secondary auxiliary is projected off a primary auxiliary, much the same as in a primary view projection.

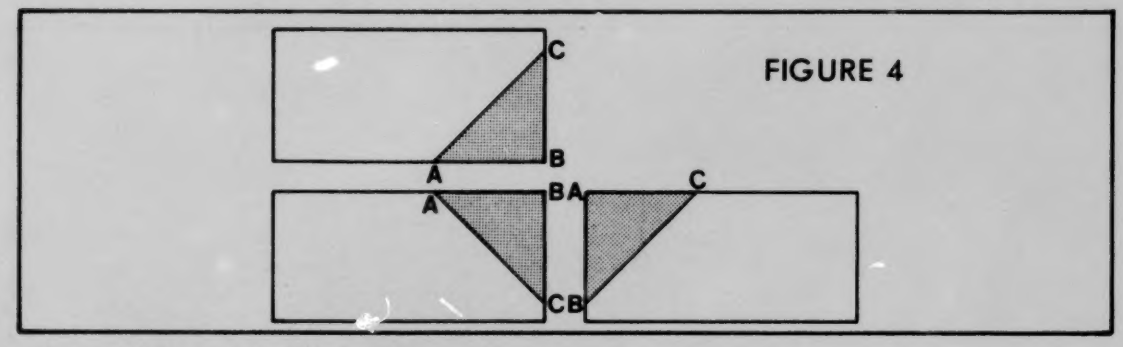


FIGURE 4

Classification of Auxiliary Views

Auxiliary views are classified according to the position they assume when projected from the principal view and the principal dimension in the auxiliary view. In Figure 5, the auxiliary view is projected from the front view, and the principal dimension is depth. This is referred to as a depth auxiliary or front view projection.

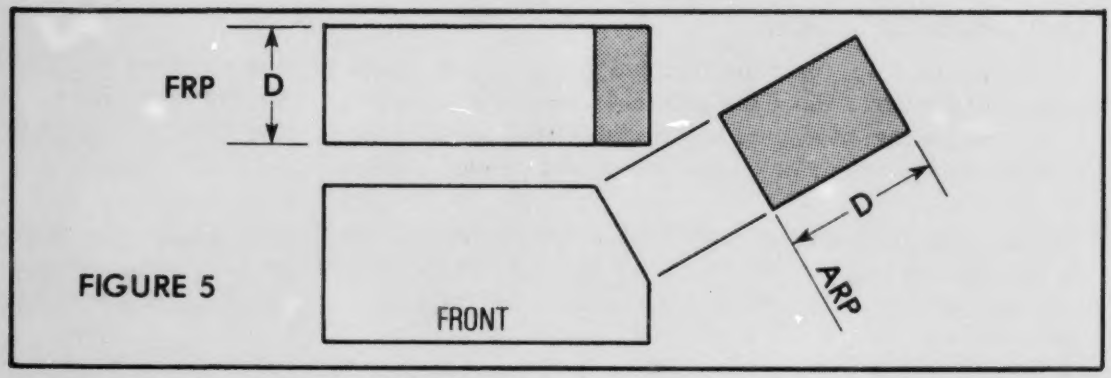


FIGURE 5

In Figure 6, the auxiliary view is from the top view, and the principal dimension is height which is taken from the front view. This type of auxiliary view is a top view projection or height auxiliary.

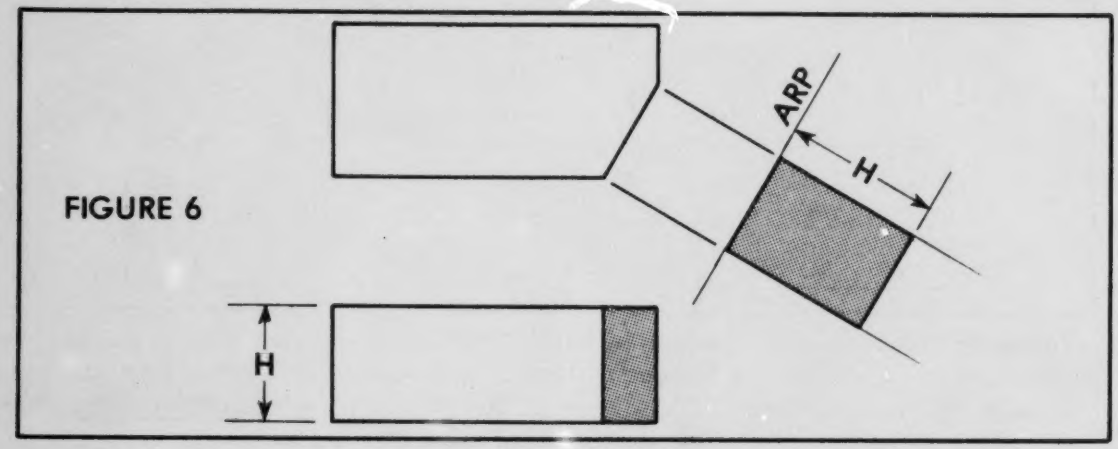
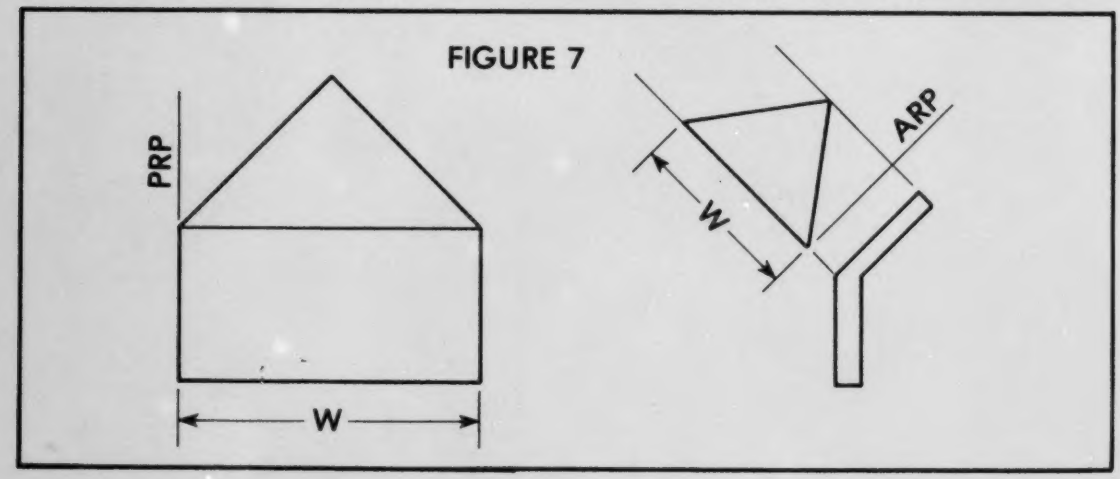


FIGURE 6

Likewise, a projection from the side view would be a width auxiliary or side view projection. See Figure 7. From this it can be cnncluded that the locatinn of the auxdliary view depends upon the position in which the object is placed when it is drawn.

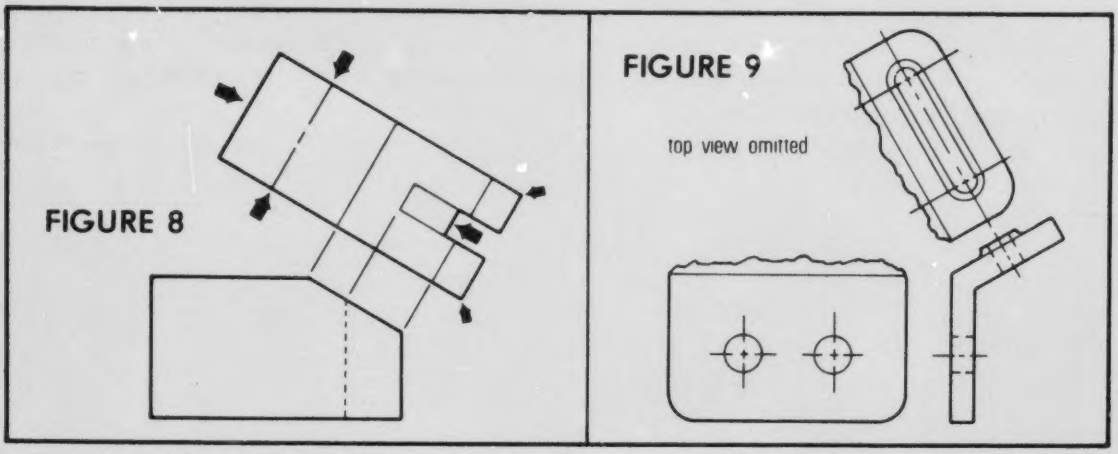
FIGURE 7



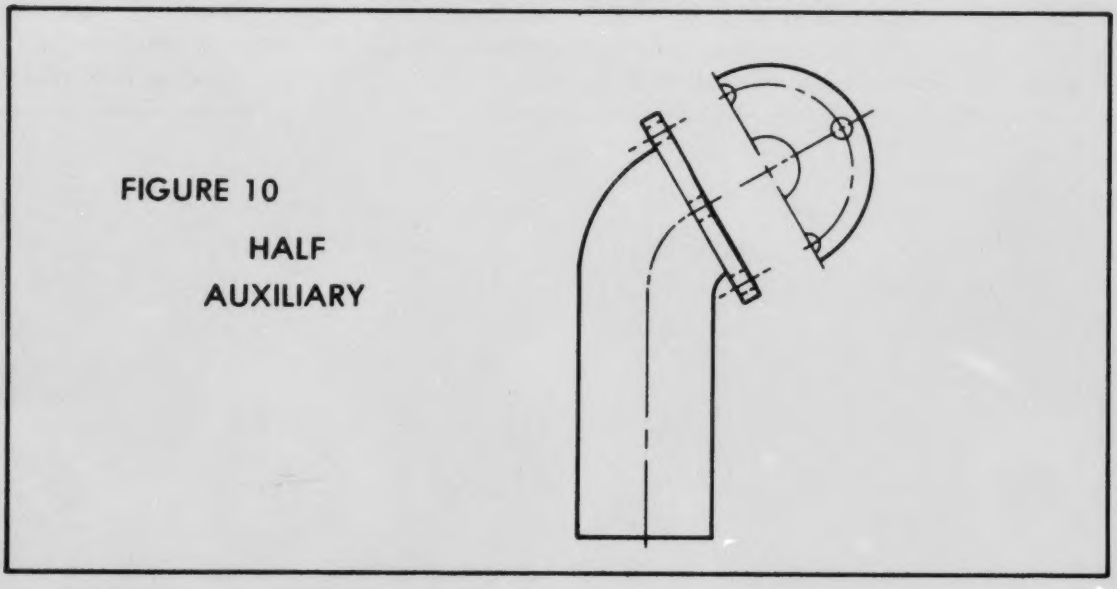
Types of Auxiliary Views

As a common rule, only the inclined surface of an object is shown and not the entire outline of the part. Since the primary purpose of an auxiliary view is to provide clarity in size and shape of an inclined surface, little would be gained by adding an auxiliary view with regular surfaces, as they would appear distorted.

The use of partial auxiliary views minimize confusing lines (Hidden lines are normally not shown) and improve the clarity of the view, as shown in Figure 8. In some cases, the need for a principal view is eliminated as illustrated in Figure 9, where the top view is omitted.



When an auxiliary view is symmetrical, only one-half of the view may be shown. As illustrated in Figure 10, the flanged fitting has only one-half presented since the other half is simply a duplication. This type of drawing is a half auxiliary view. The center line of the part is used as the auxiliary reference plane.



Types of Auxiliary Views

As a common rule, only the inclined surface of an object is shown and not the entire outline of the part. Since the primary purpose of an auxiliary view is to provide clarity in size and shape of an inclined surface, little would be gained by adding an auxiliary view with regular surfaces, as they would appear distorted.

The use of partial auxiliary views minimize confusing lines (Hidden lines are normally not shown) and improve the clarity of the view, as shown in Figure 8. In some cases, the need for a principal view is eliminated as illustrated in Figure 9, where the top view is omitted.

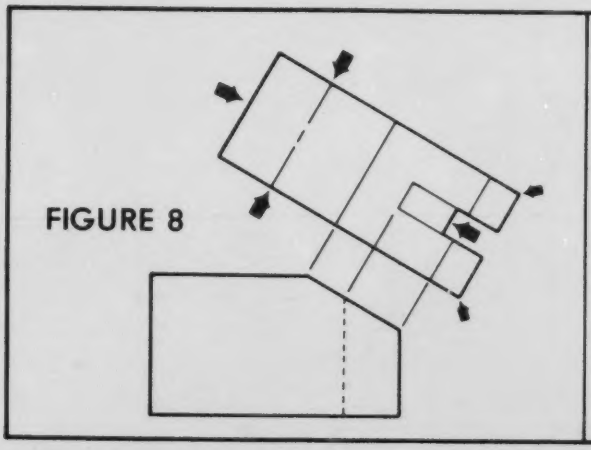


FIGURE 8

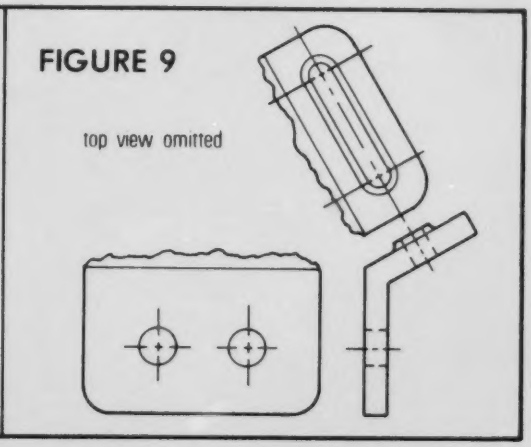


FIGURE 9

When an auxiliary view is symmetrical, only one-half of the view may be shown. As illustrated in Figure 10, the flanged fitting has only one-half presented since the other half is simply a duplication. This type of drawing is a half auxiliary view. The center line of the part is used as the auxiliary reference plane.

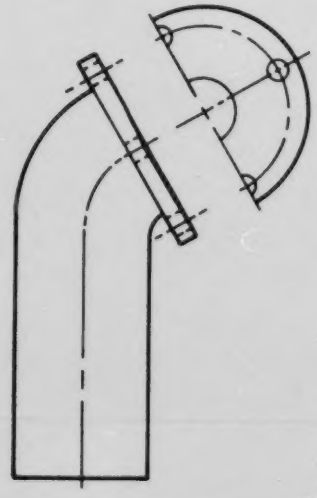


FIGURE 10

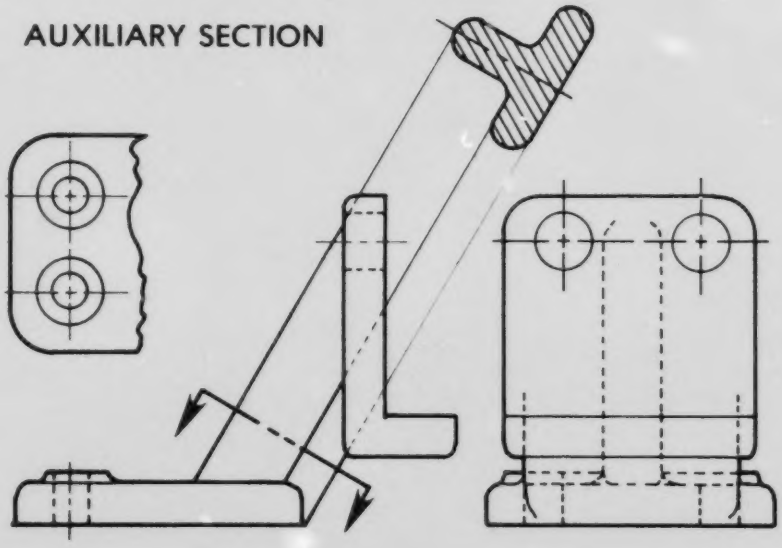
HALF

AUXILIARY

In parts that have cone surfaces, ribs, webs, or where a sectional view will clarify the drawing or aid in dimensioning, an auxiliary section is used, as shown in Figure 11. It is not uncommon to have the sectioned surface viewed alone, unless there is a need, such as for dimensioning purposes, to show the entire object behind it.

FIGURE 11

AUXILIARY SECTION



ASSIGNMENT SHEET
ON
AUXILIARY VIEWS

II-B-5(AS)

SUBJECT: Auxiliary Views

AIM: The student will be able to read a print that includes the use of auxiliary views.

INTRODUCTORY INFORMATION: Auxiliary views are aids in visualizing an object because they carry out the principle of projecting a view of an object in its true shape. This permits a more accurate method of viewing and dimensioning inclined or oblique surfaces. This assignment will provide the student experience in reading prints that include auxiliary views.

REFERENCES: Information Sheet II-B-5(IS) "Auxiliary Views"

QUESTIONS OR PROBLEMS: In the following problems, II-B-5(AS) #1 and #2, the student will study the given views of the part carefully and record the correct answer in the blank corresponding to the given statement, symbol, or dimension letter (ex. dimension "J"). Dimensions of some parts may require calculating or referring to another view.

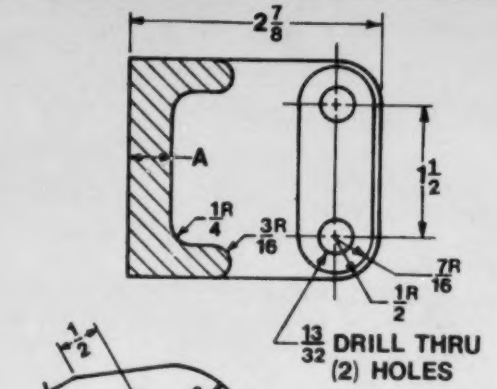
ASSIGNMENT SHEET
ON
AUXILIARY VIEWS

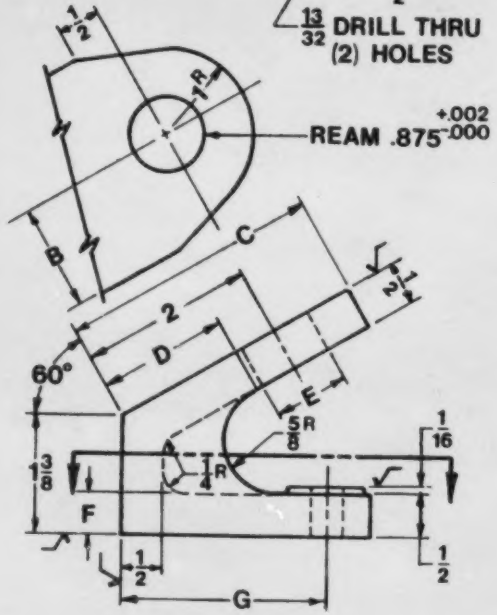
II-B-5(AS)
key
#1

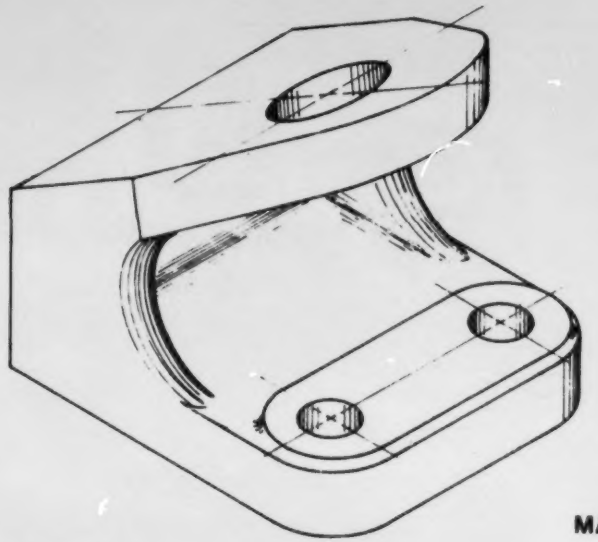
NAME_____ DATE_____

DIRECTIONS: Read and interpret the following print by recording the correct answer in the blank corresponding to the statement.

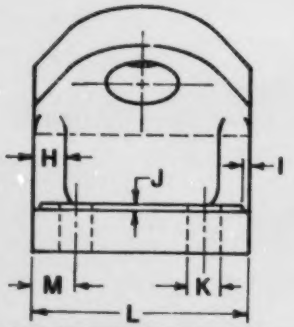
EXAMPLE:	1. Section Identification	A-A
1.	Size of drilled holes	13/32
2.	Size of reamed hole	.875
3.	Dimension "A"	$\frac{1}{2}$
4.	Inclined surface angle	30^{o}
5.	✓	finish symbol
6.	Dimension "J"	1/16
7.	Dimension "H"	3/8
8.	Dimension "L"	$2\frac{1}{2}$
9.	Dimension "B"	$1\frac{1}{4}$
10.	Type auxiliary	partial
11.	Type material	cast iron
12.	Fillet size	$\frac{1}{4}$ R
13.	Distance between drilled hole centers	$1\frac{1}{2}$
14.	Dimension "G"	2 3/8
15.	Dimension "F"	$\frac{1}{2}$
16.	Dimension "M"	$\frac{1}{2}$
17.	Dimension "I"	1/16
18.	Dimension "C"	3
19.	Dimension "D"	$1\frac{1}{2}$
20.	Thickness of inclined part	$\frac{1}{2}$







MAT'L: C.I.



TOLERANCES UNLESS OTHERWISE NOTED			
FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES + 1/4° FINISHES 125			
	DWN. BY	DATE:	DWG. NO.
	CKD. BY	SCALE:	SHT. OF

ASSIGNMENT SHEET
ON
AUXILIARY VIEWS

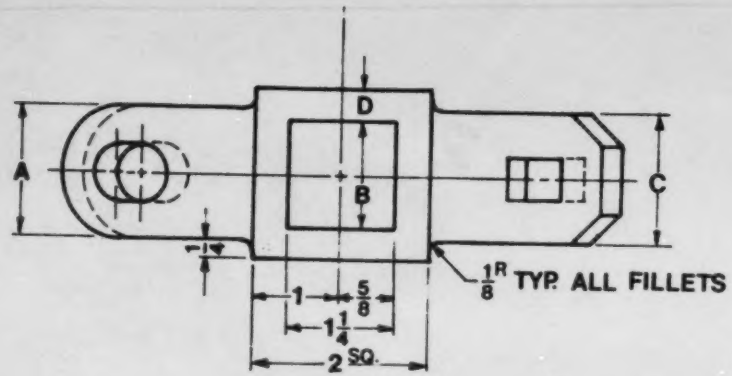
II-B-5(AS)
key
#2

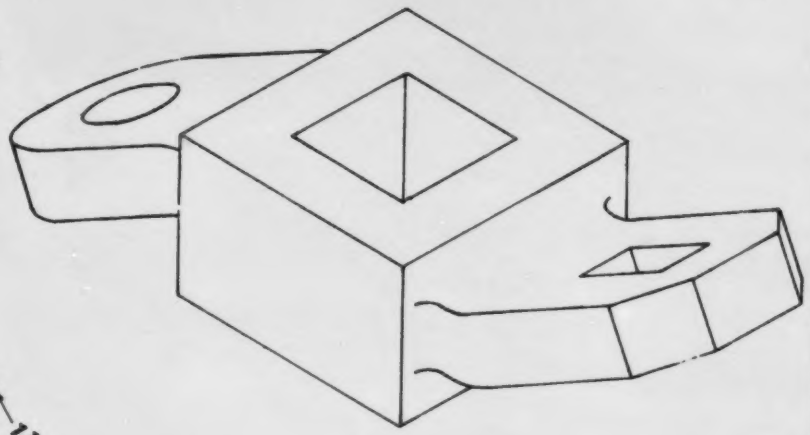
NAME_____ DATE_____

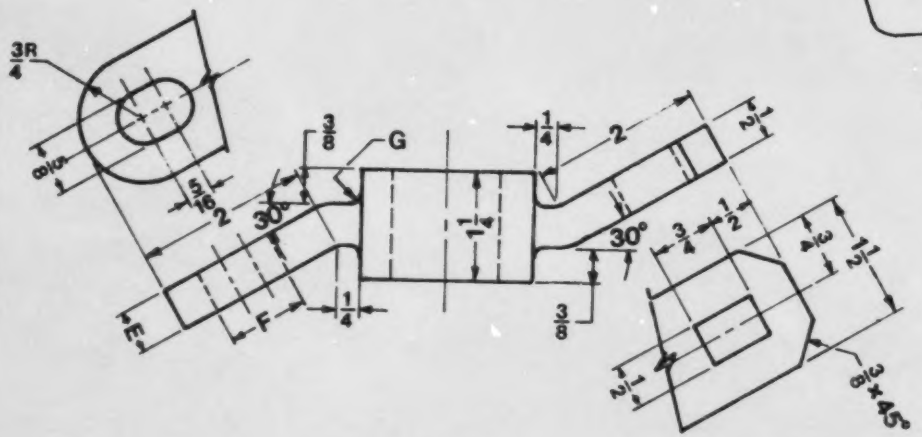
DIRECTIONS: Read and interpret the following print by recording the correct answer in the blank corresponding to the statement.

EXAMPLE: 1. Three Dimensional Drawing — pictorial

1. Size of square hole (top view) — $1\frac{1}{4} \times 1\frac{1}{4}$
2. Size of rectangular hole — $\frac{1}{2} \times 3/4$
3. Dimension "A" — $1\frac{1}{2}$
4. Dimension "D" — 3/8
5. Dimension "C" — $1\frac{1}{2}$
6. Dimension "E" — $\frac{1}{2}$
7. Angle of arms — 30^{o}
8. Dimension "G" — 1/8
9. Radius dimension of rounded end — 3/4
10. Fillet sizes — 1/8
11. Size of camfered corners — $3/8 \times 45^{o}$
12. Height of center section — $1\frac{1}{4}$







TOLERANCES UNLESS OTHERWISE NOTED			
FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES + 1/4° FINISHES 125			
	DWN BY	DATE	DWG NO.
	CKD BY	SCALE	SHT. OF

MATCHING TEST
ON
AUXILIARY VIEWS

II-B-5(T)
Key

NAME_____ DATE_____

DIRECTIONS: One statement from Column I is closely related to or associated with an item in Column II. Place the capital letter of the associated term in Column II in the blank space at the left of the number in Column I.

EXAMPLE: __A__ 1. A line not parallel to any regular plane of projection — A. Oblique

Column I	Column II
__D__ 1. Perpendicular to only one plane of projection	A. Primary auxiliary
__F__ 2. Pierces auxiliary plane at right angle	B. Hidden lines
__J__ 3. Projection of entire part	C. Secondary auxiliary
__G__ 4. Method of viewing symmetrical parts	D. Inclined line
__I__ 5. Ellipse in regular view	E. Auxiliary section
__K__ 6. Shows detail of only one part	F. Projectors
__B__ 7. Eliminated to improve clarity of view	G. Half auxiliary
__E__ 8. Auxiliary view of webs or ribs	H. Oblique surface
__C__ 9. Required to project true size of an oblique surface	I. Circle
__H__ 10. Inclined to all regular planes of projection	J. Full auxiliary
__A__ 11. First projection of an auxiliary view	K. Partial auxiliary
__N__ 12. View from which auxiliary view is projected	L. Cutting plane
__O__ 13. Auxiliary plane relationship to surface to be drawn	M. Center line
__T__ 14. Width is principal dimension in auxiliary view	N. Edge view
__P__ 15. Classification of auxiliary view	O. Parallel
	P. Height auxiliary
	Q. Depth auxiliary
	R. Leaders
	S. Visible lines
	T. Width auxiliary

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

II-C-1(I)

SUBJECT:	Orthographic Sketching
AIM:	The student will be able to explain the significance of sketching and develop those skills necessary to select the proper materials and make an orthographic sketch.
TEACHING AIDS:	Sample of freehand sketches Transparency: I. Ed. M-VIII-T, Figure 35-40 Information Sheet: II-C-1(IS), "Sketching Materials And Techniques" Information Sheet: II-C-1a(IS), "Proportion And Making An Orthographic Sketch" Test: II-C-1(T), "Orthographic Sketching"
MATERIALS:	Chalkboard, overhead projector and screen, pencils, sketching pad, and eraser
REFERENCES:	Technical Drawing Print Reading For Machine Shop
PREREQUISITE EXPERIENCE OF THE LEARNER:	The student must have completed previous assignments and have read Information Sheets II-C-1(IS) "Sketching Materials And Techniques" and II-C-1a(IS) "Proportion And Making An Orthographic Sketch"

I. PREPARATION (OF THE LEARNER - MOTIVATION)

Technical sketching is a quick and simple method of formulating, expressing, and recording new ideas or to clarify a point. A sketch is used to show what a person has in mind in a simple graphic presentation.

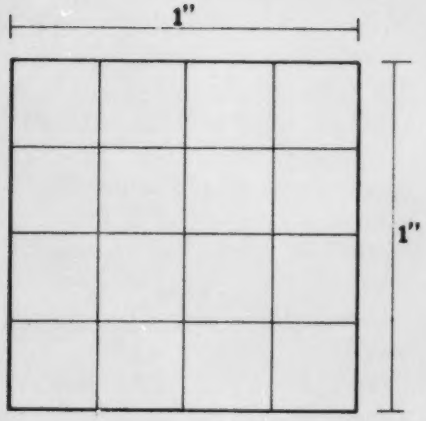
Sketching is an inexpensive method in that it requires only a sheet of paper, pencil, and an eraser. Although there are recommended grades of pencils and special types of paper and erasers, most any type can be used.

Sketching requires no absolute technique, but there are certain guides to follow in order to produce a clear drawing. These techniques include methods of sketching lines, arcs, and circles and how to sketch an object while maintaining proper proportion.

In this lesson we will study those techniques that will enhance a person's ability to produce a clear, distinct, and well proportioned sketch.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Technical Sketching	1. Oldest form of man recording ideas and thoughts 2. Basis of the mass production system 3. Means of formulating, expressing, and recording new ideas a. Assists in helping interpret technical drawings b. Used to propose new idea or clarify a point c. Preliminary drawing of idea before making a scaled drawing 4. Quick and simple method of describing an item 5. Requires minimum equipment Note: Sketch is made freehand requiring only a pencil and paper 6. Does not require artistic ability 7. Is not limited only to persons in drafting or engineering field Note: Give examples of ways machinists apply sketching 8. Sketched drawings may be: a. Pictorial sketches b. Orthographic sketches Note: Orthographic sketches will be covered in this lesson
B. Materials	1. Pencil a. Medium soft lead - F, HB, or #2 b. Sharpened to conical point c. Capable of producing light gray line for preliminary sketch or for dark sharp lines Note: Show sample of pencil properly sharpened d. Held in natural position for individual e. 1½" to 2" from point f. 50 to 60 degree angle to paper g. Rotate pencil to maintain conical point Note: Demonstrate proper procedure in holding and rotating pencil h. Light to firm pressure depending on the type of line



4 grid

2. Paper - anything may be used, but the following two are designed especially for sketching:
   a. Plain - does not contain any type of guide lines
   Note: May be transparent or opaque
   b. Coordinate - Provides means for scaling
      (1) Horizontal and vertical - lines drawn at right angle to each other
      (2) Spacing of lines determined by number of lines per inch
      Note: 4 grid would be four lines per inch
      (3) Grid size normally 4, 8, and 10 divisions per inch
      Note: Illustrate grid size on chalkboard or pass out sample sheet
      (4) Lines come in light colors - blue, green, or orange
      (5) Paper is opaque or transparent
      (6) Usually sold in pads
3. Eraser
   a. Soft eraser should be used
   Note: Avoid coarse abrasive erasers
   b. Pink pearl (pencil eraser), art gum, or vinyl eraser
   c. Available in block, stick, cap, or on pencil
   d. Keep eraser clean and free of smudges caused by oil on one's hand or face

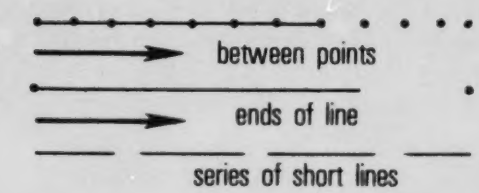
C. Line Sketching Techniques

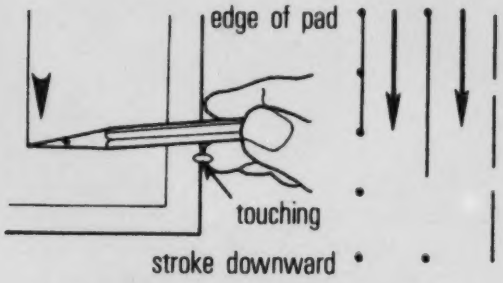
1. There are no absolute techniques for sketching
2. Each individual will develop their own technique
3. Following are some guidelines that will help produce better results

1. Straight Lines

Show: Transparency Figure 35

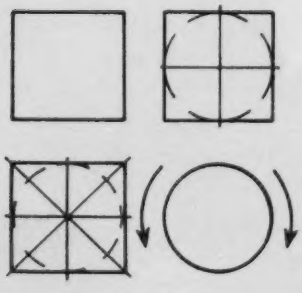
1. Will not be perfectly straight
   Note: Should be reasonably straight
2. Line should be sharp and snappy
3. Procedure for sketching
   a. Horizontal line
      (1) Sketching between two points
      Note: Point may be close or at end of line





2. Curved Lines

Show: Transparency
Figure 36



(2) Series of short lines
(3) Direction of stroke from left to right for right hand person. Reverse direction for left hand person

Note: Illustrate on chalkboard

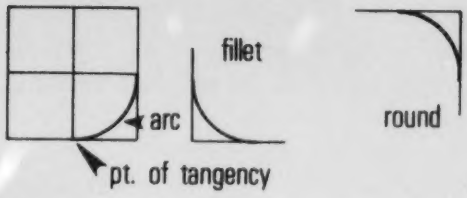
b. Vertical lines
(1) Drawn downward toward body
(2) Two point method or short line method as used for horizontal lines may be used
Illustrate on Chalkboard
(3) Marking gage method may be used for a series of parallel lines
Note: Demonstrate procedure

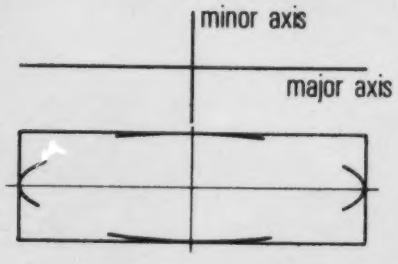
c. Inclined lines
(1) Method is same as horizontal and vertical lines
(2) Near vertical lines are drawn downward
(3) Near horizontal lines are drawn either downward or upward
Note: Illustrate on chalkboard

4. Geometric figures based on straight lines
a. Square or rectangle
(1) Lightly lay out two axes at right angles to each other
(2) Mark ½ the width and height on each side of the axes
(3) Lightly sketch square or rectangle
(4) Darken lines of square
Note: Illustrate on chalkboard

1. Circles
a. Sketch a square lightly the size of desired circle
b. Mark mid-points of square
c. Sketch light arcs tangent to sides of square
Note: 45° radial lines may be used to give more points on the circle
d. Sketch light arcs through points to form a circle
e. Darken in circle
Note: Pull pencil downward
Illustrate on chalkboard

2. Arcs (partial circles, fillets, and rounds)





a. Lay out similar to circle

Note: Small arcs may not require layout

b. Only one quadrant of square is required

Note: Mark tangency points carefully

c. Sketch in as per circle

3. Ellipses - an oblique circle
   a. Lay out major and minor axes (diameter) of the ellipse
   b. Sketch lightly enclosing rectangle
   c. Sketch arcs at tangency points
   d. Complete ellipse with light lines
   e. Darken in final ellipse

   Illustrate on chalkboard

Note: An ellipse does not have pointed ends or flat sides

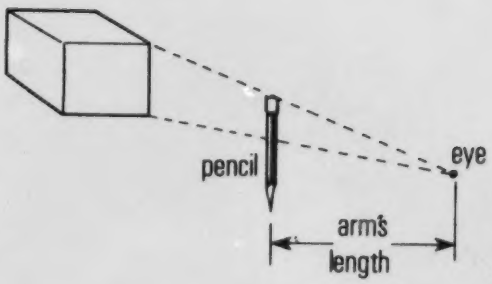
D. Proportion

Show: Transparencies
Figures 37, 38, 39

1. The most important rule in sketching is to maintain good proportion
2. Proportion is the size relationship of width, height, and depth of an object

   Note: All components should maintain a proportional relationship

3. Obtained by three different methods
   a. Approximation by eye
      (1) Fastest and most practical method
      (2) Object is studied and sizes of the various shapes are noted
      (3) Size of each shape is compared with the other
      (4) Size of each shape is compared with the overall height, width, and depth



   b. Pencil and eye
      (1) Distance on object is compared by use of pencil
      (2) Pencil is held at arm's length

      Note: Pencil must be held same distance from eye at all times

      (3) Distance is located on pencil
      (4) Each distance is marked off on sketch

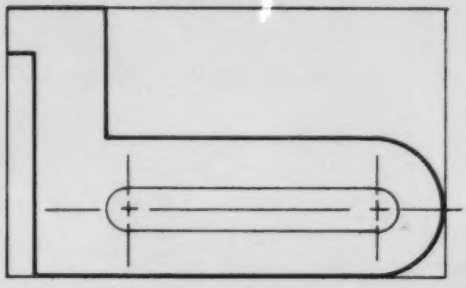
      Demonstrate

   c. Actual measurements
      (1) Most accurate method
      (2) Measurements are taken with rule, calipers, or scale
      (3) Sketch is laid out on coordinate paper

      Demonstrate

E. Procedure For Making An Orthographic Sketch

Show: Transparency
Figure 40



1. Select views to be shown
   Note: Select front view first
2. Sketch in or block in large main areas of views to be shown
   Note: Make lines very light
   Note: Maintain proportion of dimensions
3. Sketch in all center lines and centers for arcs
4. Block in construction for areas, arcs, and circles
5. Darken in all lines with sharp and snappy lines
   Note: Demonstrate making one view or three view drawings

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION).

1. Students discuss use and importance of sketching
2. Students practice sketching lines, circles, arcs, and ellipses
3. Students practice methods of determining size proportions
4. Student complete assignment sheets on sketching

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENTS' COMPREHENSION OF MATERIALS PRESENTED).

Essay Questions

1. The materials required for sketching are:
   1. pencil
   2. paper
   3. eraser
2. What is the purpose in rotating or revolving a pencil when sketching?
   Keeps pencil point conical, thereby maintaining uniform lines
3. What are the advantages in using coordinate paper in sketching?
   1. Provides means for scaling drawing to size
   2. Provides lines as a guide for sketching

4. Three methods of obtaining good proportion in sketching are:

   1. Approximation by eye
   2. Use of pencil and eye
   3. Take actual measurement

5. The steps in making an orthographic sketch are:

   1. Select views to be shown
   2. Block in the overall size of the object
   3. Lay out center lines for circles and arcs
   4. Block in construction for all areas, circles, and arcs
   5. Darken all lines

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT).

Technical sketching is a simple, quick, and inexpensive way of formulating, expressing, and recording new ideas.

A sketch should be properly proportioned and drawn with sharp and accurate lines. Three methods of determining good proportion is by (1) approximation of the eye, (2) use of pencil and eye, and (3) by scaling the part to be sketched.

Certain techniques are essential to good sketching. These techniques consist of sharp and snappy lines drawn reasonably straight and the uniform construction of arcs and circles.

The proper selection of views is essential to clarity and must be made maintaining good proportion and proper position.

In making an orthographic sketch the following steps should be followed:

1. Select the views to be shown
2. Block in large main areas
3. Lay out center lines for circles and arcs
4. Block in construction for circles, arcs, and other areas
5. Darken in final lines

SUGGESTED READING FOR THE STUDENT:

II-C-2(IS) "Pictorial Sketching"

The Next Lesson Is: II-C-2(I) "Pictorial Sketching"

INFORMATION SHEET
ON
TECHNICAL SKETCHING

II-C-1(IS)

SUBJECT: Sketching Materials And Techniques

INTRODUCTORY
INFORMATION:

Sketching is the oldest form of recording one's thoughts. Evidence has been found showing that the pre-historic caveman used sketches to show the spot where an animal could most easily be wounded or killed.

Throughout the ages sketching has been used as a definite aid in recording shape descriptions. Records show that perhaps the greatest inventive genius in history, Leonardo da Vinci, filled sketch books with illustrations which fully described his ideas.

Today as in the past, sketching continues to be a form of conveying information or ideas from one person to another or as a means of developing an idea.

Sketching, as it is used in industry, is the right hand of technology. In the shop a sketch is used to assist someone in understanding a print; to explain a new idea such as a tooling requirement; or to explain an operation. The sketch may be made on an envelope, sketch pad, or a paper towel. It does not require artistic talent or mechanical tools to produce a technical sketch. All that is required is a basic understanding of the step-by-step principles and practices used in making a clear and comprehensive sketch.

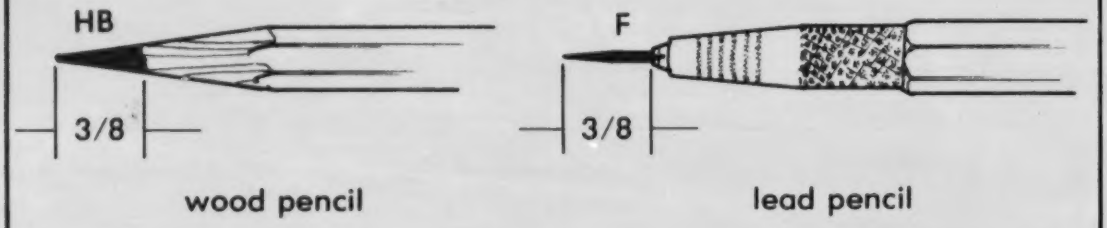
GENERAL INFORMATION

Sketching Materials

One of the advantages in technical sketching is that materials used for sketching are few and sketching can be done at any place or at any time. The only material requirements are a pencil, eraser, and paper, although some type of holder, such as a clip board or sketching pad, may be required to hold and support the paper.

The pencil used can be any type, although a medium soft pencil such as an F or HB drawing pencil or a common #2 writing pencil is preferred. A medium soft pencil is used because it can produce a soft gray line for the preliminary block-in of the sketch and also give a sharp or nearly sharp line, depending on the type of line required. With a hard lead it is difficult to produce a black line.

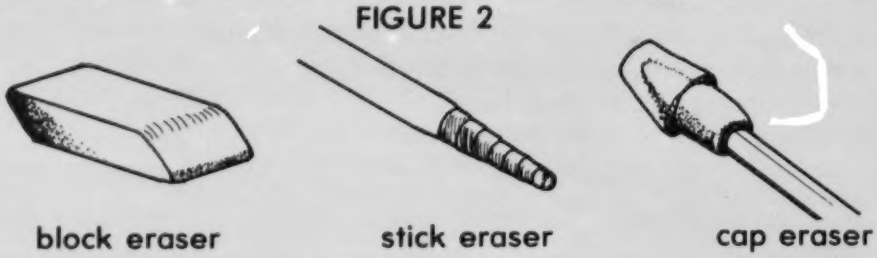
FIGURE 1



To produce quality lines requires the pencil to be sharpened correctly. A correctly sharpened pencil has a long (approximately 3/8") conical point, as in Figure 1. Note: The point may be kept sharp by using a sanding pad or pencil sharpener.

Although the eraser on a pencil can be adequately used, a soft eraser such as the pink pearl or vinyl type is recommended. Both types are available either in block or stick form, as in Figure 2. Ink erasers are not recommended since the eraser contains coarse abrasive materials that will damage the paper.

FIGURE 2



Coordinate paper is recommended for sketching, although any type of paper can be used. The ruled lines of the paper provides a guide for sketching lines straight and square and provides a means of sketching to scale. Cross-section paper or coordinate paper, as it is called, usually is divided into 4 spaces ($\frac{1}{4}$" squares), 8 spaces (1/8" squares), or 10 spaces (1/10" squares), as illustrated in Figure 3, and is usually sold in pads similar to a tablet. It is either printed on heavy opaque or thin transparent paper. The lines are printed in a light color such as orange, blue, or green. Special types of ruled paper are also available for special drawings, such as isometric sketch paper, shown in Figure 3, that is used in making an isometric pictorial drawing.

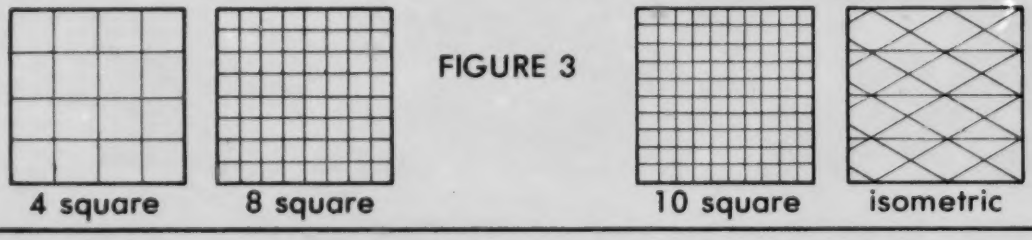


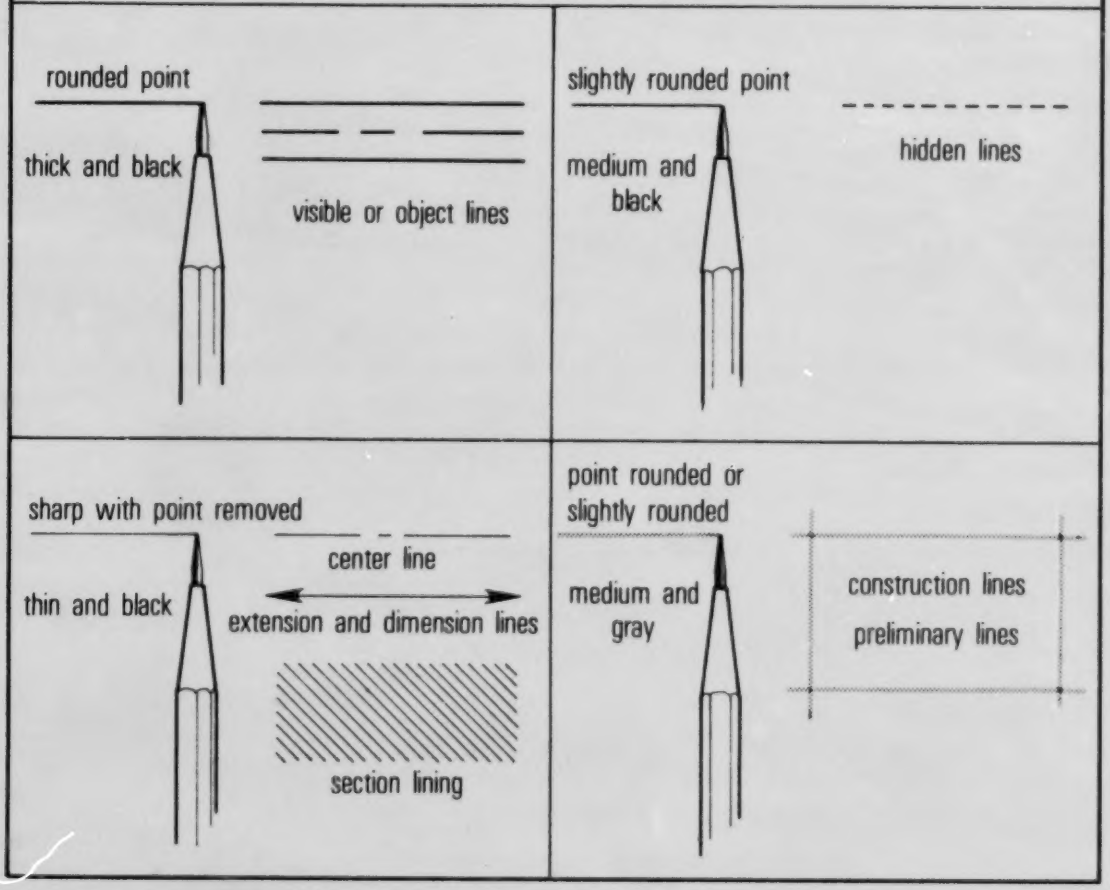
FIGURE 3

Sketching Techniques

Even though there is no absolute rule for sketching techniques, there are a few recommendations that will help in making a good sketch. Among these are proper methods of holding the pencil; sketching different line thicknesses; erasing techniques; and sketching straight and curved lines.

The pencil should be held in a natural position, usually at a 50^{o} - 60^{o} angle to the paper and about $1\frac{1}{2}$ to 2" from the point. As a line is drawn, the pencil should be rotated to keep the point from wearing flat. This may be done by turning the pencil approximately 1/6 revolution after each sketched line. Pressure on the pencil should be constant, allowing the point of the pencil to determine proper line weight. See Figure 4.

FIGURE 4

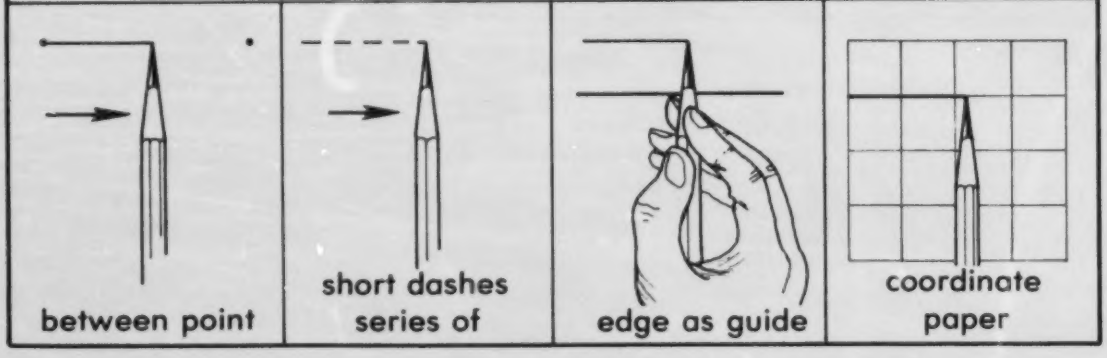


The appearance of any sketch can be ruined if erasing techniques are careless and sloppy. Erasers should be clean and free of oil and dirt from one's hands. Erasing pressure should be light so as to prevent smudging or tearing the paper. The eraser can be cleaned by rubbing on a scrap piece of paper prior to erasing.

Sketching of straight lines will vary with the individual and will not be perfectly straight, but every effort should be made to make the line reasonably straight with a certain degree of freedom for individual character desired.

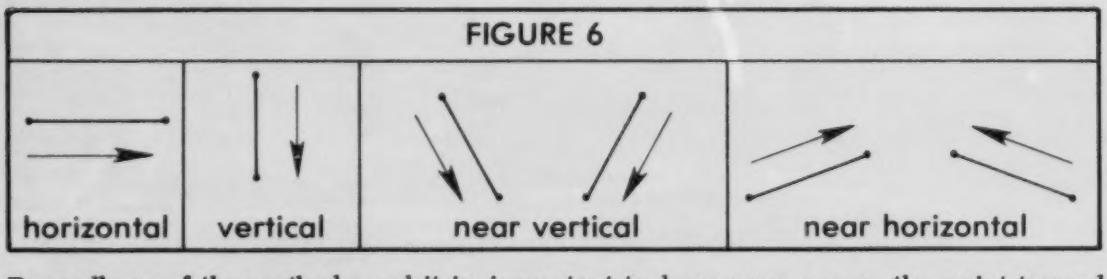
There are three basic straight lines used in sketching. They are: horizontal, vertical, and inclined lines. Each line may be sketched neatly by using one of four techniques: (1) mark extreme ends of line with two points and move pencil from one point toward other; (2) by sketching a series of short lines; (3) using the edge of the paper as a guide; and (4) using the lines of coordinate paper as a guide. Study methods below in Figure 5.

FIGURE 5



The direction the pencil is moved will be determined by the type of line - vertical, horizontal, or inclined - and whether the person is left or right handed. For a right handed person horizontal lines are drawn from left to right. A left handed person would draw from right to left. Vertical lines are drawn from top to bottom or downward. The direction of inclined lines will be either downward for near vertical lines and upward for near horizontal lines. See Figure 6 for illustration of each.

FIGURE 6



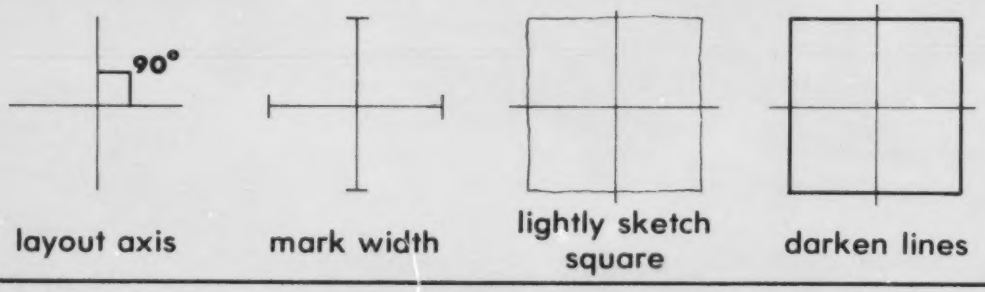
Regardless of the method used it is important to keep your eye on the point toward which you are drawing and to maintain a free and easy wrist-and-arm motion.

Sketching Geometric Shapes

Any object that may be viewed is made up of basic geometric shapes, such as squares, rectangles, triangles, and circles or curved lines. It is important that each shape be described accurately. This may be done by having a knowledge of the geometric shape and the technique that will assist in best describing the shape.

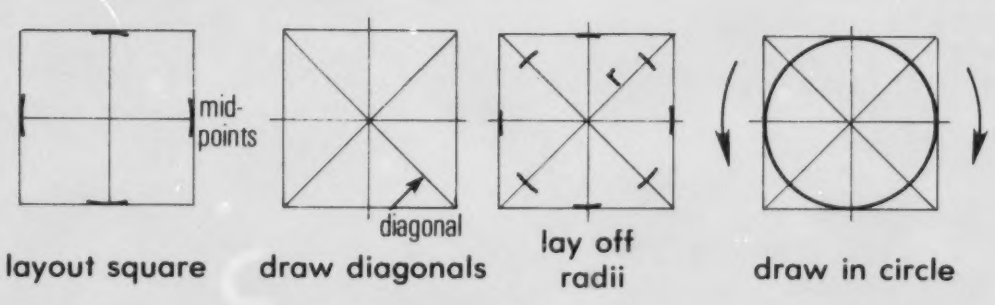
Squares and rectangles can best be sketched by laying out two axes at right angles to each other, and then with the use of the pencil as a gage lay out the height and width. Sketch horizontal and vertical lines through the point as in Figure 7.

FIGURE 7



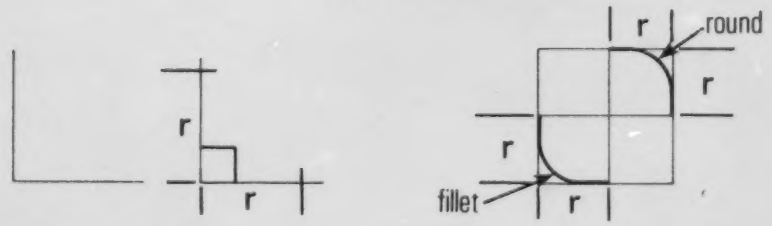
Circles and arcs are easily sketched by first lightly drawing a square the size of the circle or arc. Figure 8 shows the procedure used to sketch a circle.

FIGURE 8



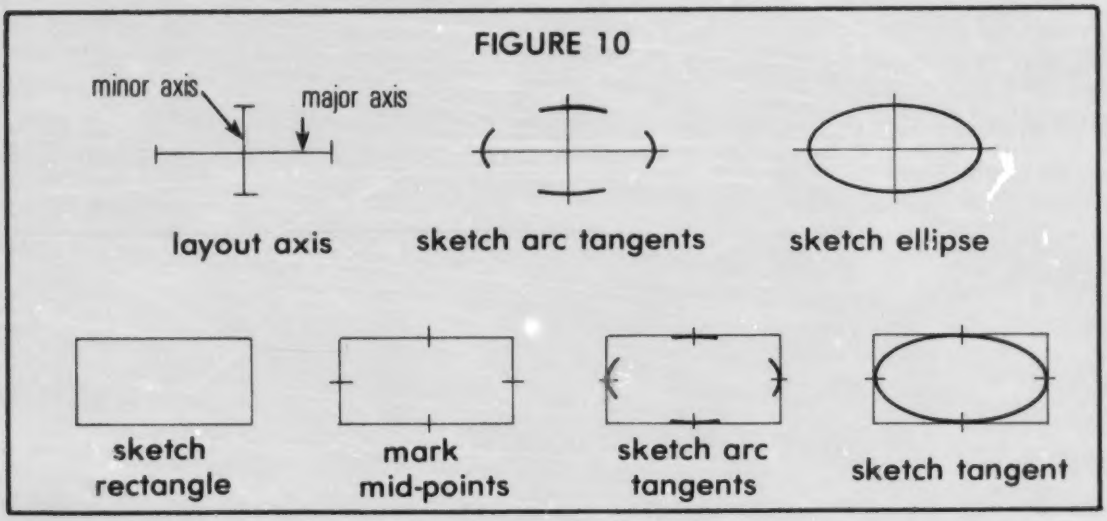
Arcs are sketched in the same way except only one quadrant of the circle is used, as shown in Figure 9.

FIGURE 9



A circle viewed at an angle appears as an ellipse. Instead of all points on the curve being equidistant from the center, there are two axes. One axis appears shorter than the other. The long axis is called the major axis and the short axis is the minor axis. Figure 10 illustrates two methods of sketching an ellipse.

FIGURE 10



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ASSIGNMENT SHEET
IN
SKETCHING

II-C-1(AS)

SUBJECT: Sketching Straight and Curved Lines

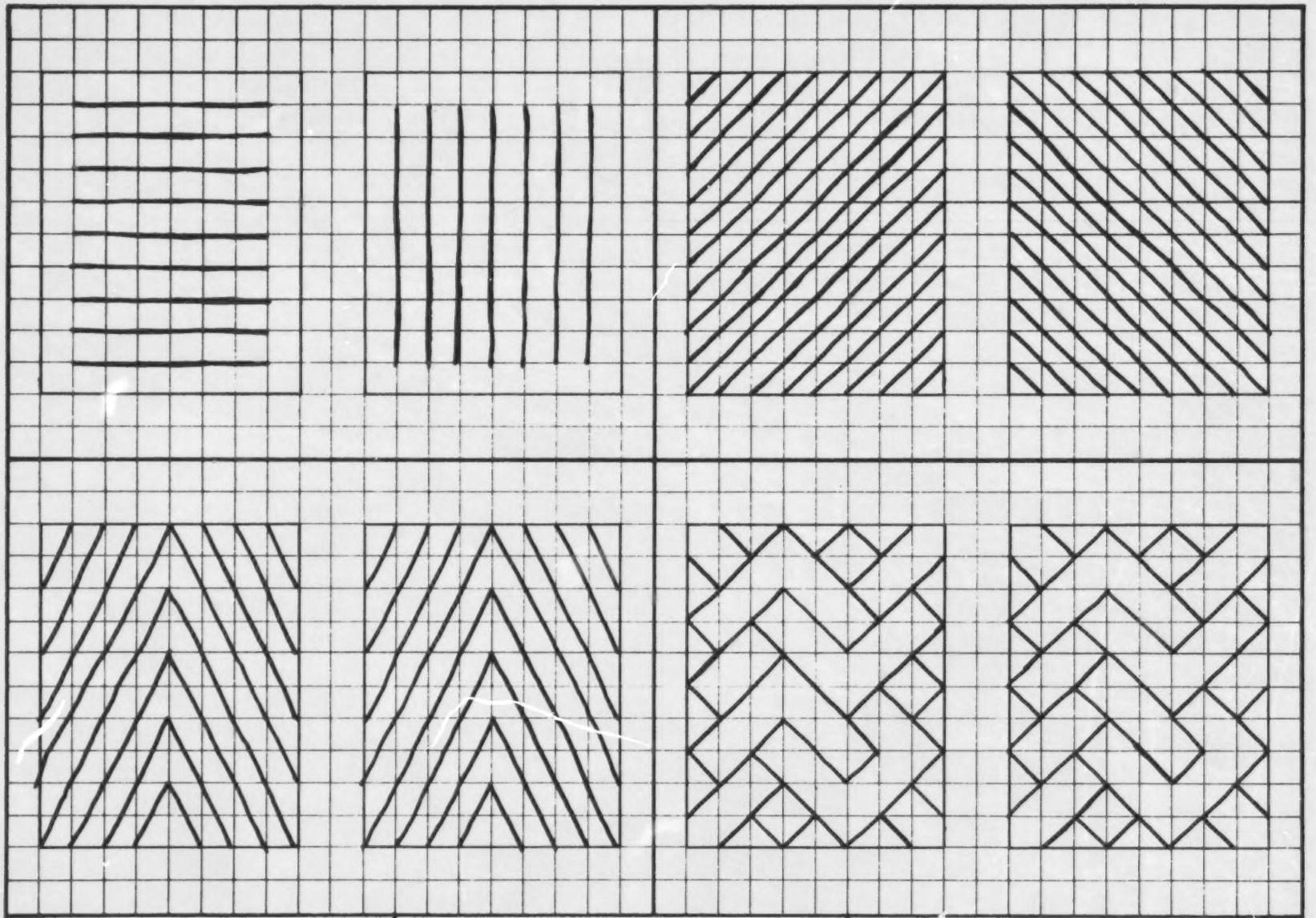
AIM: The student will exhibit skill in the technique of sketching straight and curved lines and the selection of materials used in sketching.

INTRODUCTORY INFORMATION: Sketching is a quick and simple method of formulating, expressing, and recording new ideas or clarifying a point. Although sketching requires no absolute technique, there are certain guidelines one should follow in order to produce a neat and clear drawing. These techniques include methods of sketching lines, arcs, and geometric figures and maintaining proper proportion when sketching. This Assignment Sheet will enhance the student's ability to sketch clear, distinct, and uniform lines and geometric figures that are essential in orthographic or pictorial sketching.

REFERENCE: Information Sheet II-C-1(IS) "Sketching Materials and Techniques"

QUESTIONS OR PROBLEMS:

1. Assignment Sheet II-C-1(AS) Number 1 develops the skill of the student in sketching straight lines, including horizontal, vertical, and inclined. Each problem has an illustration of the skill the student is to develop by duplicating the illustrated skill. The student is expected to complete the problems, working to maintain clean, sharp, distinct lines as discussed in Information Sheet II-C-1(IS) "Sketching Materials and Tecniques".
2. In Assignment Sheet II-C-1(AS) Number 2, the student will develop skill in sketching curved lines such as arcs and circles. Each problem has a partial illustration of the skill the student is to perform by completing the illustration and duplicating it. All curved lines should be sketched with sharp, distinct, and smooth curved lines. All construction lines used to lay out the circle should be drawn lightly so as to give contrast to the drawing. Information Sheet II-C-1(IS) "Sketching Materials and Techniques" is to be used as a guide in developing these skills.



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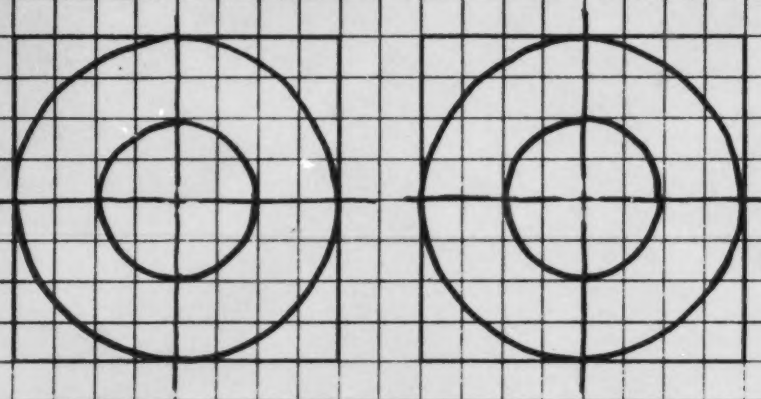
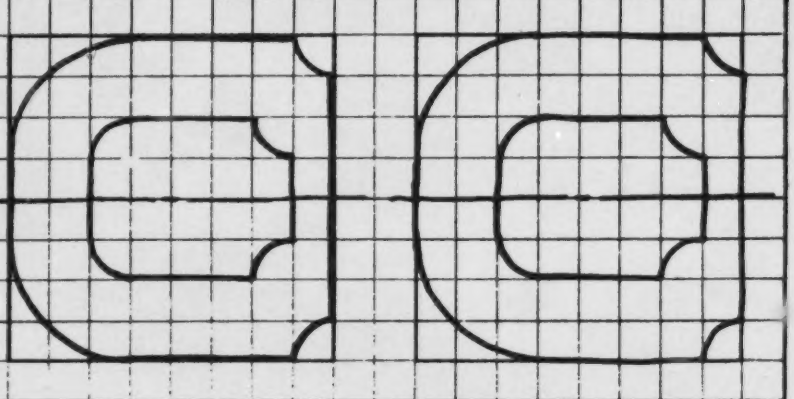
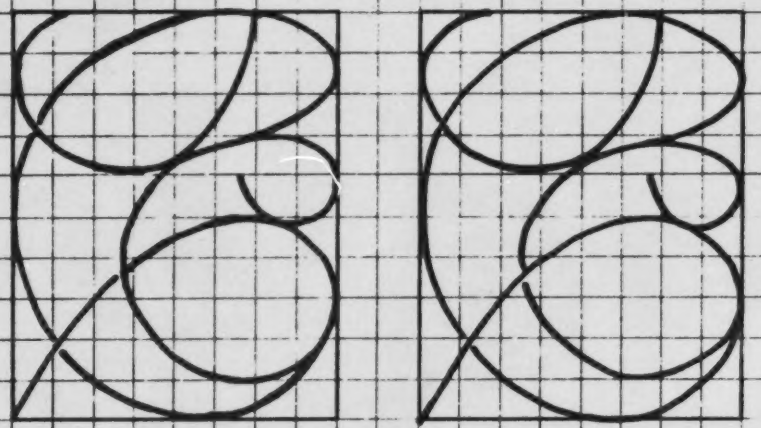


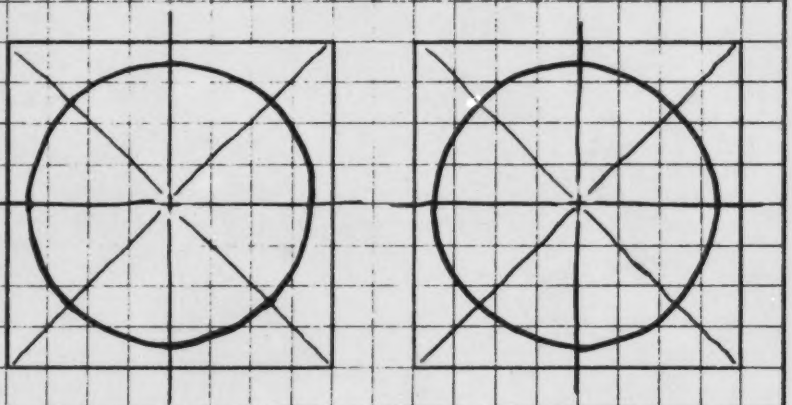
1. COMPLETE CIRCLES AND DUPLICATE IN SPACE TO RIGHT.



2. SKETCH LOWER HALF SYMMETRIC. DUPLICATE DESIGN AT LEFT.



3. DUPLICATE DESIGN SHOWN AT LEFT.



4. SKETCH CIRCLE THROUGH POINTS MARKED. DUPLICATE CIRCLE AT LEFT.

NAME: INSTRUCTOR'S KEY	ORTHOGRAPHIC SKETCHING	DATE:	2

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INFORMATION SHEET
ON
TECHNICAL SKETCHING

II-C-1a(IS)

SUBJECT: Proportion And Making An Orthographic Sketch

INTRODUCTORY
INFORMATION:

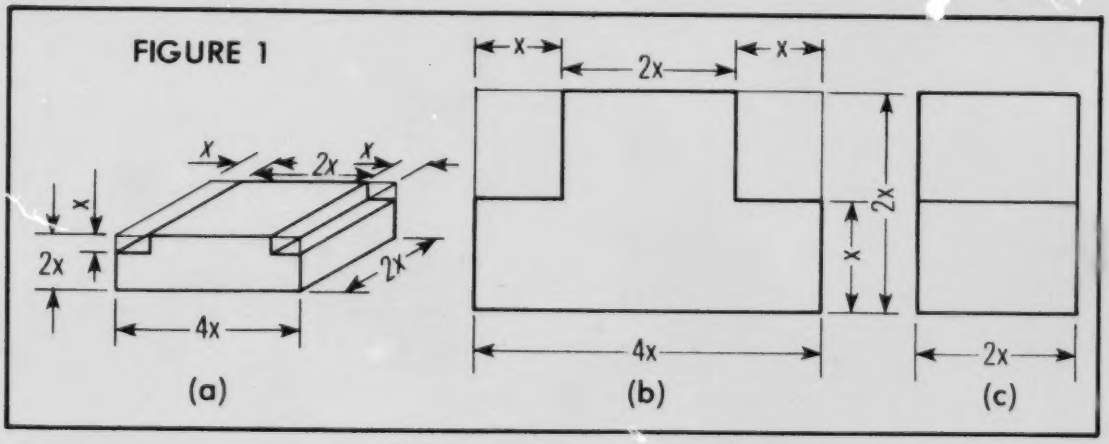
There is an old saying, "be the labor great or small, do it well or not at all." This saying applies especially to sketching. Proportions "make or break" a sketch, whether a single view, multi-view, or a pictorial sketch. Proportion is the size relationship of the component of an object to each other and with the whole size of the object. It also can be defined as making the component parts of an object harmonious or symmetrical through their size relationship. Regardless of how well the view selection and line techniques, if the proportions of an object are bad, the sketch will appear bad. This is especially true of the large overall proportions.

Estimating Proportion

Proportion may be determined by three different methods. They are (1) approximation by eye; (2) approximation by pencil and eye; and (3) actual measurement. The method used will be greatly determined by what is to be sketched and the availability and size of the object. An object that can be measured will provide more accurate information, while large objects will require estimation by eye, or by eye and pencil. New ideas will require personal knowledge of good proportion.

The method of obtaining proportion through approximation by eye is the most practical and quickest method since no measurements are made. The object to be sketched is carefully studied and the sizes and shapes of component parts are noted. The size of the various shapes are compared with each other and with the overall height, depth, and width of the object. This relationship is obtained by comparing general areas and distances visually, as in Figure 1(a).

FIGURE 1



The overall height and width of the front view is blocked in lightly. The basic shape and component parts are then blocked in, as in Figure 1(b). The depth and height is compared and the end view is blocked in, as in Fig. 1(c). All object lines are then darkened in.

The use of the pencil and eye method of obtaining proportion is frequently used by artists and engineers. In this method a pencil is held at arm's length and sighted along the object, as in Figure 2, and noting the length on the pencil. The lengths are transferred to the sketching paper as measured or by using the same proportion. It is very important to position the pencil the same distance from the eye each time in order to maintain proper proportion, as the dimension will increase or decrease if the hand is moved closer or farther from the eye.

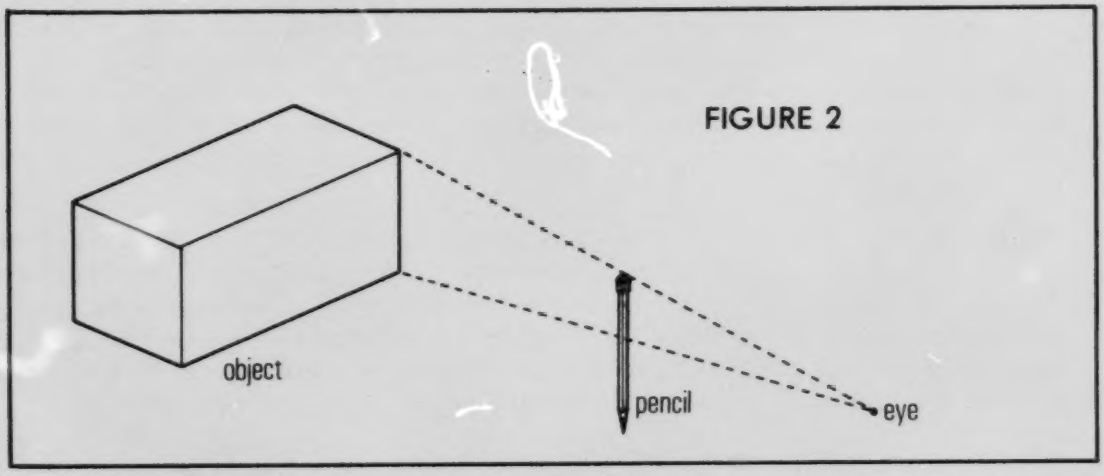


FIGURE 2

For small parts, such as a machine part, the distance can be compared in the same manner by actually placing the pencil against the object itself, as in Figure 3. This method is frequently used in the shop.

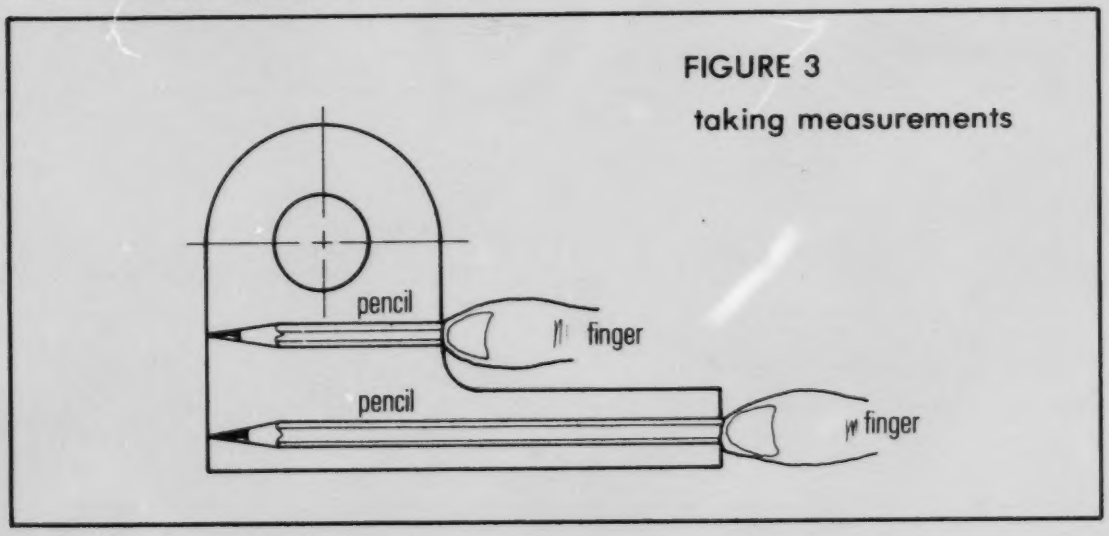
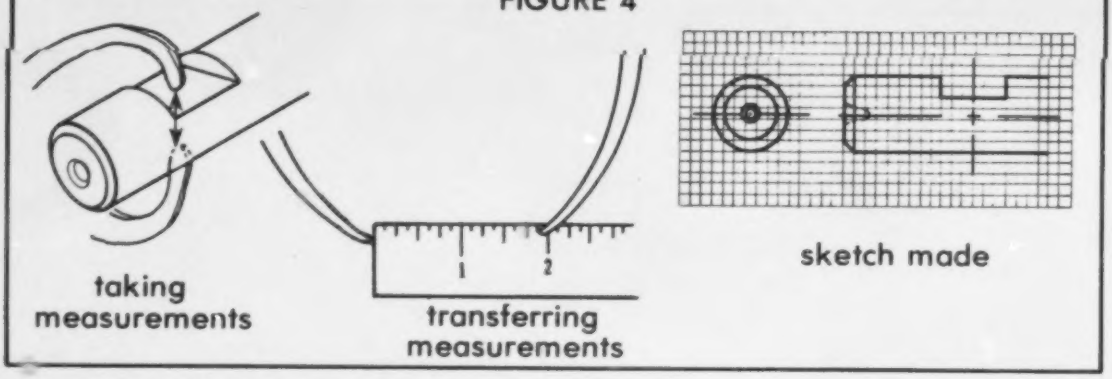


FIGURE 3
taking measurements

The most accurate and widely used method in the shop is to take actual measurements of the part and transfer them to coordinate paper. The sketch is drawn full size or to a scaled size, as in Figure 4. Measuring tools such as calipers, micrometers, or just a ruler are used in taking the measurements, as in Figure 4.

FIGURE 4

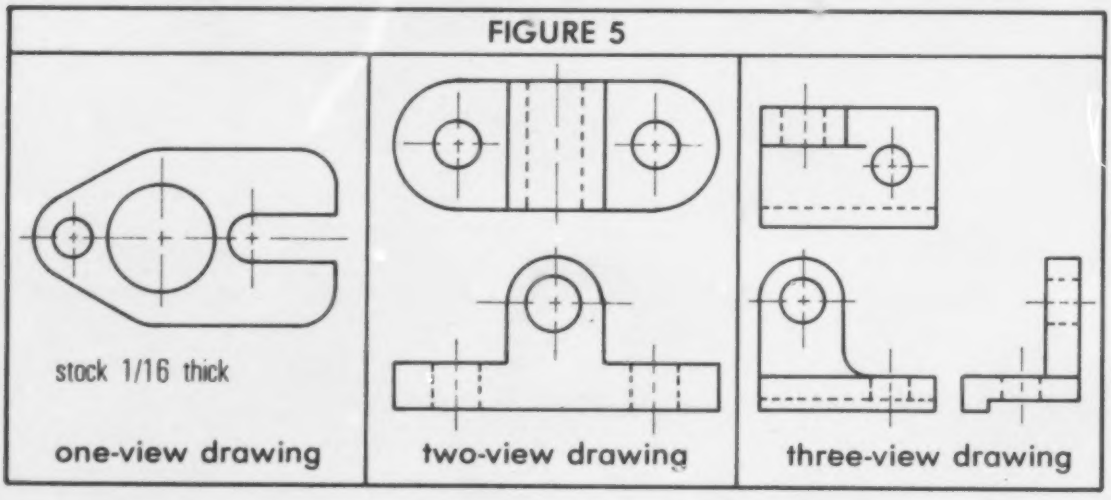


Orthographic Sketching

As true with any type of drawing, the orthographic sketch must give that information necessary to convey the idea, thought, or plan. The sketch may consist of a single view or multi-view drawing with or without dimensions applied. Regardless of the information to be given, there are steps or procedures that may be followed to produce a clear comprehensive sketch. The following procedure is recommended:

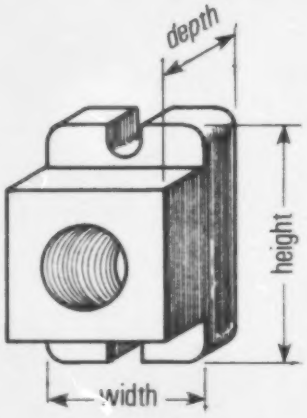
1. Select the views required. This may be one, two, or more views depending on complexity of part and information to be given. Select only the views needed for clear and complete shape description. Views that show best the essential contours or shapes with the minimum number of hidden lines are preferred, as in Figure 5. The front view should be selected first as it is the most important view and usually shows the shape of the object most clearly.

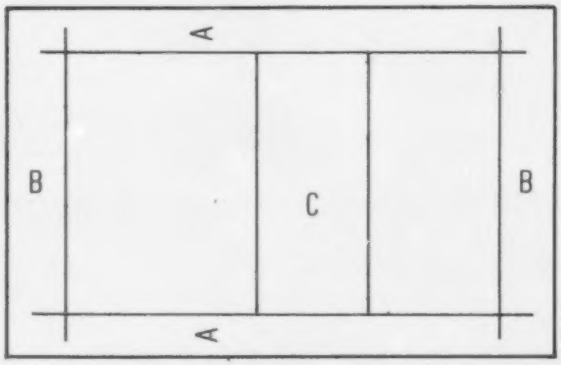
FIGURE 5



2. Block in views. The overall depth, height, and width are blocked in lightly with horizontal and vertical lines to establish the correct size proportion. Space is left between each view and the edge of the paper to provide a margin and room for dimensions and note, as shown in Figure 6 by spaces A, B, and C.

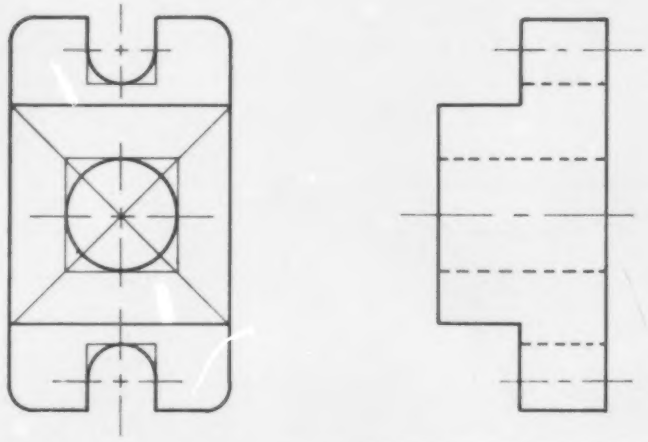
FIGURE 6





3. Locate center and arcs and block in smaller details. The center lines for all circles are located and blocked in, as are minor areas. Diagonals are drawn to locate the centers of the arcs and circles as illustrated in Figure 7.

FIGURE 7

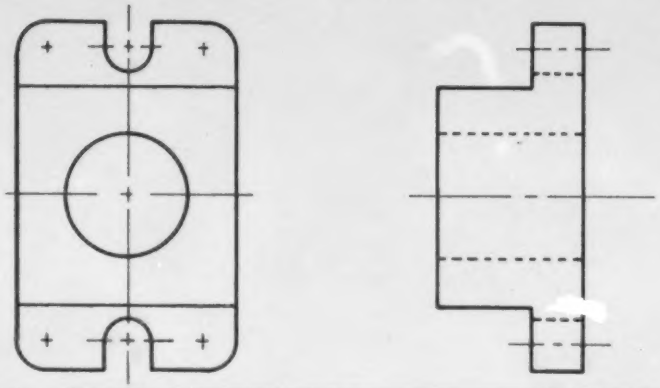


4. Darken in all visible lines - straight and curved. All visible edges are darkened with a sharp and snappy dark line. Straight lines should blend into curved lines at the tangent point. See Figure 8.

5. Darken in centers and center lines with sharp thin lines. Centers for small arcs are located with a small t. See Figure 8.

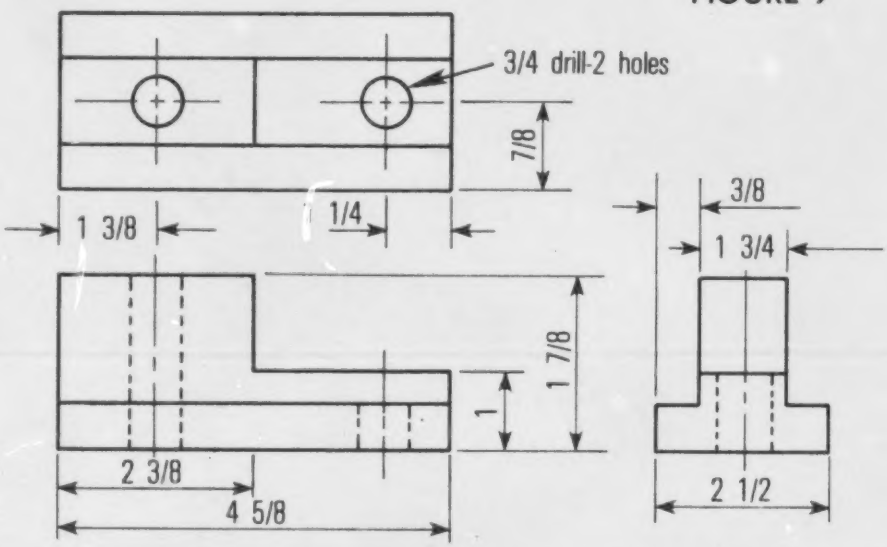
6. Darken in all hidden lines with medium lines, as seen in Figure 8.

FIGURE 8



7. Draw in extension lines, dimension lines, leader lines, and dimension part. At this point of a sketch all information relating to shape description has been given. In some cases, this will be all that is needed. If the sketch is to be used as a working drawing the application of dimensions will be required. The principles of dimensioning are complicated and have many rules and procedures. Although it would be well to know all of these practices, it is not practical to try and learn them as the person in the drafting department would, in such short time. One can learn through the experience of reading prints and the common knowledge of machine shop practices. Figure 9 illustrates some basic dimensioning techniques. It is important to remember that the sizes of all geometric shapes and their location with respect to each other be given as you have studied in previous lesson.

FIGURE 9



ASSIGNMENT SHEET
IN
SKETCHING

II-C-1a(AS)

SUBJECT: Orthographic Sketching

AIM: The student will exhibit skill in making an orthographic sketch.

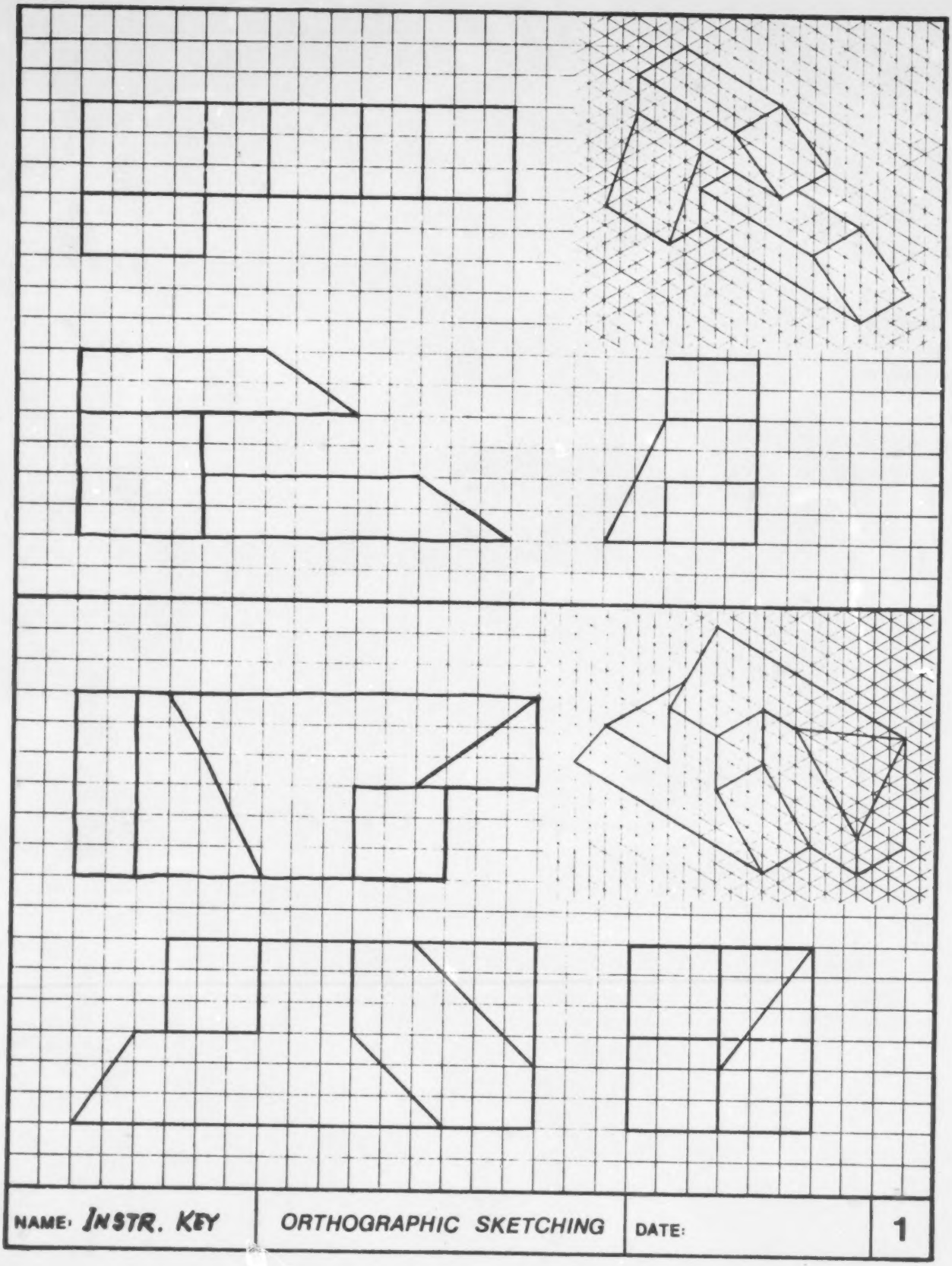
INTRODUCTORY INFORMATION: An orthographic sketch does not require the exactness that is essential in a mechanical drawing, but there are certain techniques that are essential. In an orthographic sketch all lines must be shown and made correctly. The lines should be sharp and distinct, giving a contrast between the different types of lines, such as hidden lines and visible lines. Center lines are necessary to locate centers of arcs and circles, and construction lines should be used for the initial layout. Where dimensions are to be used, dimensioning techniques studied in Information Sheets II-B-3(IS) and II-B-3a(IS) are to be followed. The student should constantly observe good line work as practiced in Assignment Sheet II-C-1(AS) "Sketching Straight and Curved Lines". The constant practice of good proportion should be observed, since poor proportion will make the overall sketch poor. This assignment will enhance the student's ability to make a clear, distinct, and well proportioned sketch.

REFERENCES: Information Sheet II-C-1(IS) "Sketching Materials and Techniques"
Information Sheet II-C-1a(IS) "Proportion and Making An Orthographic Sketch"

QUESTIONS OR PROBLEMS:

1. Assignment Sheet II-C-1a(AS) will provide the student with problems in making an orthographic sketch. Problems 1 and 2 have a pictorial view of the object to be sketched with two orthographic views given. The student will study the pictorial drawing and the two given views and complete the missing view. Care should be taken to show all lines and sketch each line neatly and correctly. The coordinate grid and isometric grid are to be used to provide size proportion.
2. Problems 3 and 4 provide the student with a greater challenge in that only the pictorial sketch and the location of key centers are provided. The student will study the pictorial view and sketch the top, front, and right side views. The coordinate and isometric grid will provide the student with a reference for size proportion.
3. Problem 5 will enhance the student's ability to develop a sense of proportion in sketching. The student will study the given pictorial view and sketch the top, front, and right side views. The sketch is to be made using the student's own perception

of proportion, rather than a formal measuring tool, such as a rule or divider. The student is to strive for good proportion in addition to good line work and correctness of the drawing.



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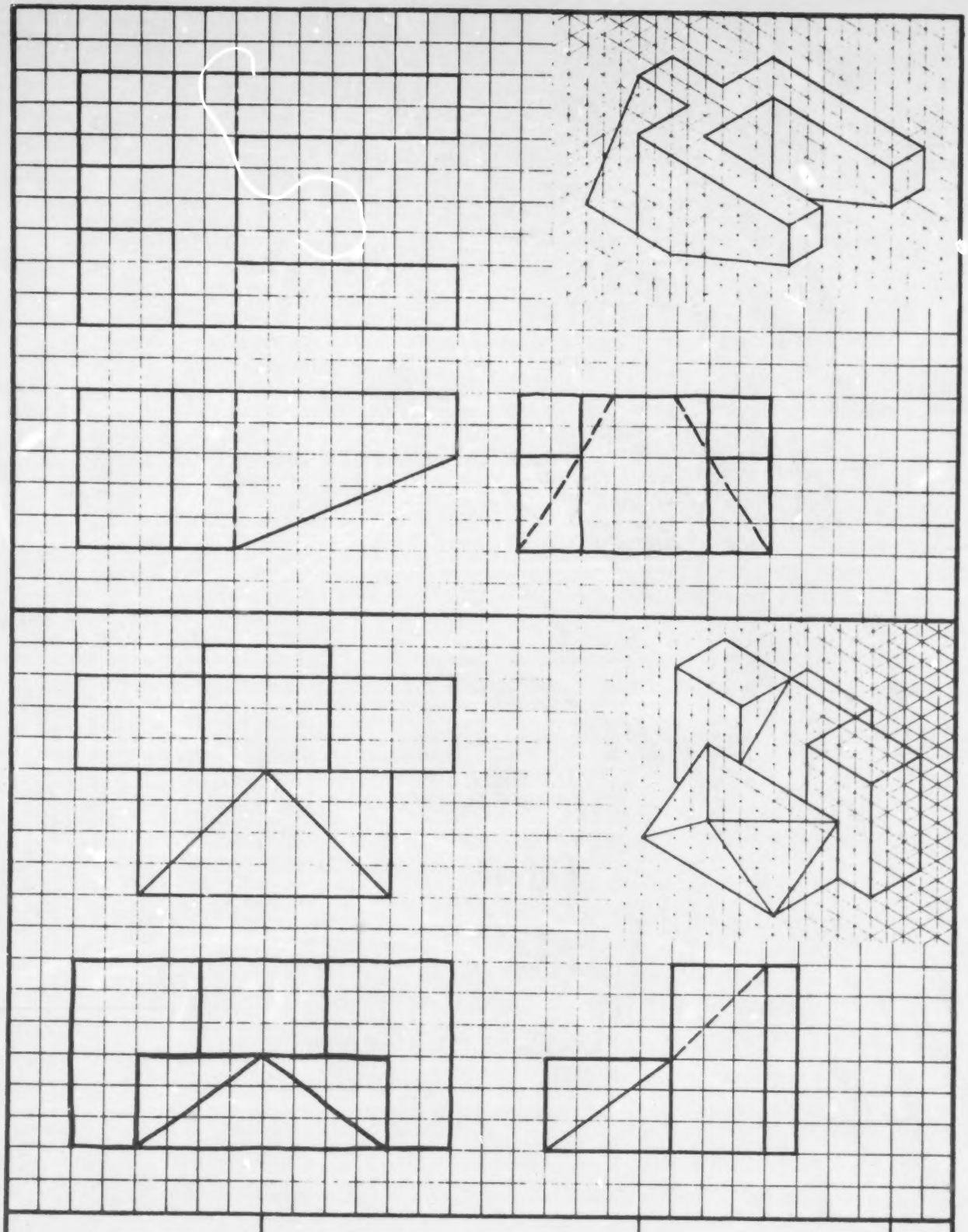

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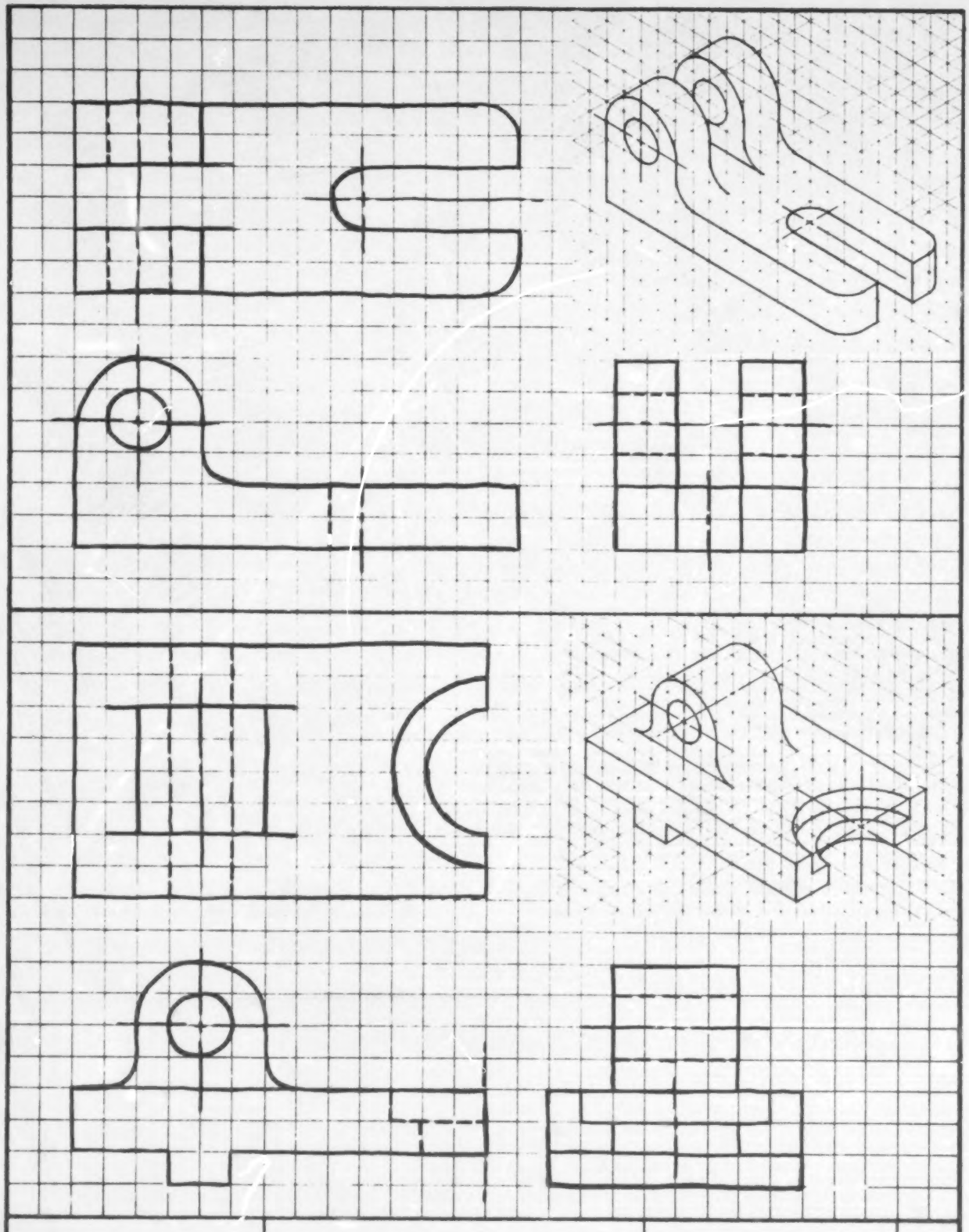

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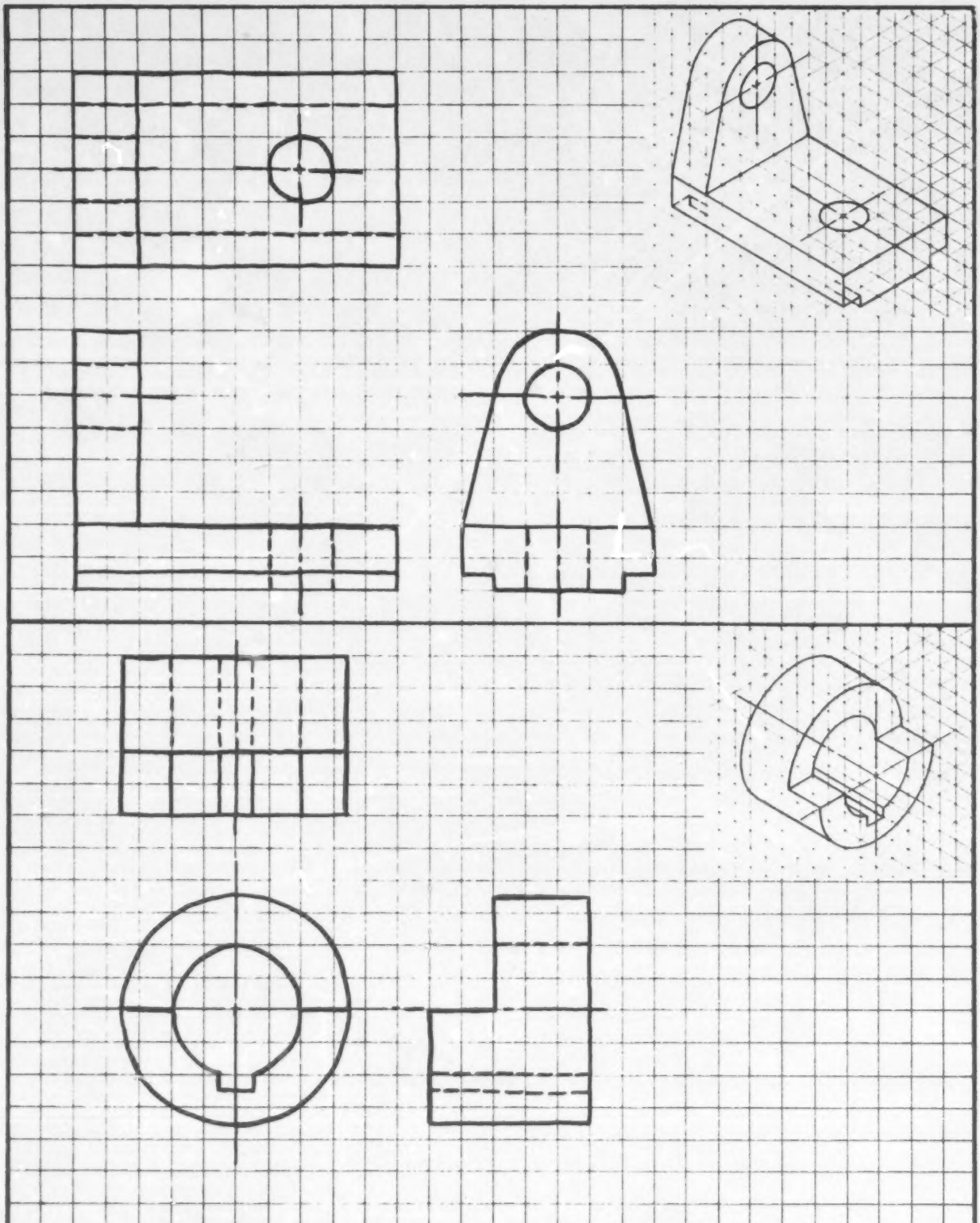

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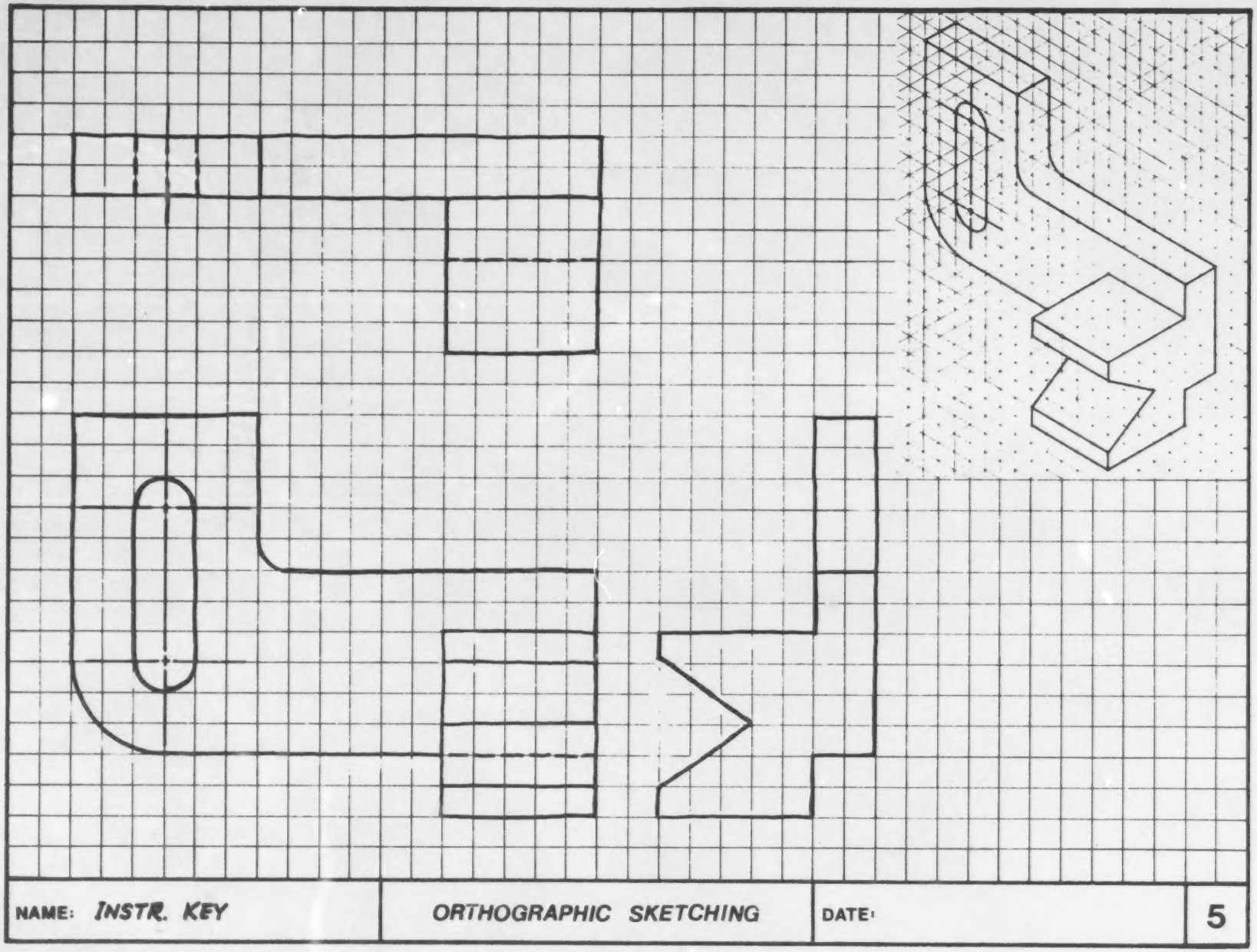
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5

TRUE - FALSE TEST
ON
ORTHOGRAPHIC SKETCHING

NAME_____ DATE_____

DIRECTIONS: Read each of the following statements carefully. Some of the statements are true and some are false. Indicate the correct answer by placing a small circle around the T or F in the corresponding right hand column.

EXAMPLE: 1. Leonardo da Vinci was an inventive genius. T

1. Sketching is a form of technical drawing that requires the use of mechanical drawing instruments. F
2. Sketches can be either pictorial or orthographic drawings. T
3. An advantage of technical sketching is that the required material is inexpensive. T
4. Four grid coordinate paper has 16 squares per square inch. T
5. Ink erasers will give a clean erasure without damage to the paper. F
6. Light will penetrate opaque paper. F
7. Lines on coordinate paper inclined to each other. F
8. Sketching allows for a certain amount of individuality in the line work. T
9. The construction of a sketched circle is developed from a square. T
10. Proportion of a drawing is the size relationship of the component parts to each other. T
11. The proportion of a drawing is of little importance to a drawing. F
12. The number of views to be drawn is determined by the complexity of the drawing. T
13. Coordinate paper provides an accurate method of sketching a drawing to scale. T
14. A circle viewed at an angle will appear as an ellipse. T
15. A 3H pencil is recommended for sketching. F

16. Rotating a pencil while sketching will prevent the pencil point from wearing flat. T

17. Visible or object lines are drawn thin and black. F

18. Construction lines are used to block in a drawing. T

19. Vertical lines are drawn by pulling the pencil upward from bottom to top. F

20. The direction an inclined line is drawn is determined by the angle of the line. T

21. The largest diameter of an elliqse is called the major axis. T

22. Rotation of the pencil will help maintain sharp and uniform weight of lines. T

23. The normal direction for sketching a horizontal line for a right handed person is from right to left. F

24. To clean a dirty eraser one should wash the eraser. F

25. Rulers are a common tool used for taking measurements of a part. T

MATCHING TEST

DIRECTIONS: One item from Column I is closely related to or associated with an item in Column II. Place the capital letter of the associated term in Column II in the blank space at the left of the number in Column I.

EXAMPLE: __C__ 1. Angle pencil is held

A. Perpendicular
B. Horizontal
C. 50 - 60 Degrees

Column I	Column II
__I__ 1. Permits light to pass through	A. Ink eraser
__M__ 2. Freehand drawing	B. Tangent
__R__ 3. Size relationship	C. Coordinate
__F__ 4. Circle viewed at an angle	D. HB
__L__ 5. Shape of pencil point	E. Major axis
__A__ 6. Coarse abrasive material	F. Ellipse
__C__ 7. Sketching paper with squares	G. By eye
__O__ 8. Short axis of an ellipse	H. Rotate pencil
__G__ 9. Quick method to determine proportion	I. Transparent
__E__ 10. Largest diameter of an ellipse	J. Arc
__B__ 11. Point where curved and straight line blend together	K. Opaque
__D__ 12. Medium soft lead	L. Conical
__H__ 13. Required to maintain conical point	M. Sketch
__S__ 14. Geometric figure with four equal sides	N. Hole
__J__ 15. Portion of a circle	O. Minor axis
	P. Eye and pencil
	Q. 4H
	R. Proportion
	S. Square
	T. Rectangle

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

II-C-2(I)

SUBJECT:	Pictorial Sketching
AIM:	The student will be able to explain the various types and uses of pictorial drawing and develop those skills necessary to make a pictorial sketch.
TEACHING AIDS:	Sample of various pictorial sketches Transparencies: I. Ed. M-V-II-T Figures 41-46
MATERIALS:	Chalkboard, overhead projector and screen
REFERENCES:	Technical Drawing Print Reading for Machine Shop
PREREQUISITE EXPERIENCE OF THE LEARNER:	The student must have successfully completed previous assignments and have read Information Sheet II-C-2(IS) "Pictorial Sketching".

I. PREPARATION (OF THE LEARNER - MOTIVATION)

In previous lessons we have concerned ourselves only with orthographic views which require great skill in visualization in order to sketch or read a given print.

Frequently it becomes necessary to make a drawing that is accurate but easily understood, especially by non-technical trained persons. The drawing is made in three dimensions and viewed so that three faces of the object are seen in one view. This type of drawing is called pictorial drawing.

There are three basic types of pictorial drawings: axonometric, oblique, and perspective. In this lesson we will study the principle of each of these types of pictorial drawings and how to make an isometric and an oblique sketch.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Pictorial Drawings	1. Three faces of an object viewed in a single view 2. Supplement multi-view drawings 3. Assist untrained person in visualization 4. Extensive uses consist of: a. Sales catalogs and literature b. Technical books and illustrations c. Assembly drawings d. Simple presentation of an idea or object
Show: Transparency Figure 41	

5. Excellent for showing overall appearance
6. Three basic types:
   a. Axonometric - principal edges and surfaces inclined to plane of projection
   b. Oblique - one face is parallel to plane of projection and viewed in true size and shape
   c. Perspective - receding lines converge on a common point in the distance
7. Classified by position of front face with plane of projection and the projection of receding line
   a. Angle
   b. Scale or size

B. Axonometric Drawing

1. Principle

1. Principal edges and surfaces inclined to plane of projection
2. Lengths of receding lines and angles vary
3. General proportion varies
4. Circles and arcs are shown as an ellipse
5. Principal edges form axonometric axis

2. Classification

There are three classes:

1. Isometric - most commonly used

   Note: Sketching will concern only isometric sketching

   a. Principal edges or axes make equal angle with plane of projection

   Note: Spaced 120^{o} apart

   b. Edge lengths are foreshortened equally
   c. Receding lines are drawn 30 degrees to horizon
   d. Corner edges appear vertical
   e. Principal edges form isometric axis and are referred to as isometric lines
   f. Line not parallel to isometric axis must be located on axis

      Note: Referred to as non-isometric line

   g. Circles and arcs will appear elliptical

2. Dimetric

   a. Two principal axes make equal angle with plane of projection
   b. Third axis makes either greater or smaller angle
   c. Two axes are foreshortened equally

Show: Transparency
Figure 42

d. Third axis foreshortened with different ratio

3. Trimetric
   a. No two axes make equal angle with plane of projection
   b. No two axes are foreshortened equally

3. Sketching Materials
   1. Good quality pencil
   2. Eraser
   3. Paper
      a. Plain paper
      b. Coordinate paper
      c. Isometric paper

4. Sketching Procedure-Isometric
   1. Drawing is built on isometric axis
      Note: Position axis to illustrate best view
   2. Isometric axis is laid out
   3. Principal dimensions are laid out on axis
      Note: These are true length dimensions
   4. Overall object is blocked in
      a. Dimensions laid out along isometric axis
      b. Center lines for circles and arcs are located
      c. Circles and arcs are blocked in
      Note: An isometric square is used to lay out ellipse
      d. Non-isometric lines are located
      e. All lines are darkened in
      Note: Demonstrate making isometric sketch on chalkboard

Show: Transparency Figure 43

C. Oblique Drawing

1. Principle
   1. Front is viewed in true size and shape
      Note: As in orthographic sketching
   2. Receding (depth) lines project at any angle
      Note: 30, 45, and 60 degree angles are most common
   3. Receding lines project true length or to size
   4. Circles and curved surfaces appear elliptical in receding views

Show: Transparency Figure 44

2. Classification
   Classification based on:
   a. Angle of receding line
   b. Scale axis is drawn to
   1. Cabinet
      a. Most frequently used
      b. Receding lines project 45° angle
      c. Depth projected half size
      d. Overall appearance more natural

2. Cavalier
   a. Depth projected full length
   b. Angle of projection either 30, 45, or 60 degrees
   c. Object appears distorted
3. General
   a. Depth projected at any scale
   Note: Reduced to provide most natural appearance
   b. Angle of projection normally 30 or 60 degrees

3. Materials
1. Material same as in orthographic sketching
2. Paper
   a. Plain paper
   b. Coordinate paper
   Note: May be opaque or translucent

4. Position of Object
1. Most descriptive features should be faced toward the front
   Note: Circles, curves, and arcs are drawn true size and shape
2. Largest dimensional face should be placed to front
3. Angle of receding axis should provide clear detail of receding face
   Note: Increase of angle provides greater detail of the top of the object
4. Arcs and circles not facing the front will appear as ellipses
   Note: Method of sketching a circle would be same as in sketching an isometric circle

5. Procedure
1. Selection of front view is made
2. Front view is sketched as in an orthographic drawing

Show: Transparency Figure 45
3. Layout of oblique (receding) axis is made
   Note: Selection of angle determined by receding views, normally 45^{o}
4. Principal dimensions of the object are laid out on the axis
   Note: Length is determined by type of drawing
5. Overall object is blocked in
6. Details are sketched in
   a. All dimensions are laid out along the oblique axis

b. Center lines for circles and arcs are laid out and blocked in

Note: Circles and arcs that lie on the receding face require a parallelogram enclosed as in sketching an isometric circle

c. Arcs and circles are sketched in

7. Unneeded lines are erased
8. All lines are darkened in

Note: Demonstrate on chalkboard the procedure for making an oblique sketch of an object

D. Perspective

1. Object viewed as eye perceives it
2. Becomes progressively smaller as viewed farther away
3. Primary use is in sales promotions

Note: Most common use is in architecture

Show: Transparency Figure 46

4. Two common types are:
   a. Parallel (one point perspective)
      (1) Front face is viewed in true size and shape
      (2) Parallel lines converge to a common vanishing point (depth and width)
   b. Angular (two-point perspective)
      (1) Most true to life type projection
      (2) Two vanishing points are located on the horizon
      (3) Receding lines project from the corner edge to the two vanishing points

      Note: Corner edge has no vanishing point

      (4) Depth and width dimensions are laid out along projectors

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION).

1. Students discuss the various types of pictorial sketches as to the type, use, advantage, and disadvantage.
2. Students discuss the selection of view that will provide the best description of the object.
3. Students review method of sketching ellipses.

4. Students complete assignment sheets.

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENTS' COMPREHENSION OF MATERIALS PRESENTED).

Simple Recall

1. Pictorial drawings have 3 faces of the object viewed in a single view.
2. Three basic types of pictorial drawings are axonometric, perspective, and oblique.
3. Isometric drawings are developed along an isometric axis.
4. Isometric lines projecting width and depth are drawn approximately 30 degrees to the horizontal.
5. Circles as in an isometric view will appear as an ellipse.
6. The front face of an oblique drawing is viewed in true size and shape.
7. The receding lines of a cabinet drawing are reduced to one-half size.
8. The lines of the isometric axis appear 120 degrees apart.
9. The term "isometric" means equal measure.
10. Isometric sketches are made on either coordinate paper or isometric paper.

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

A pictorial drawing is a graphic presentation whereby three faces of an object are viewed in a single view. The pictorial drawing is used to supplement the multi-view drawing by giving an overall appearance of the object. This is used in technical illustrations, assembly drawings, or as a means of assisting an unskilled person in print reading.

The two basic types of pictorial drawings commonly used are:

1. Isometric - The object is inclined and rotated to plane of projection. The horizontal lines and corner edges form an isometric axis in which the lines are 120° apart. Lines that form the isometric axis are drawn full size. Arcs and circles will appear elliptical and are developed from an isometric square.
2. Oblique - The front view of the drawing is viewed as in a multi-view drawing. Lines projecting depth will be projected at any angle, although 30°, 45°, and 60° are the most common. Receding lines are drawn full size in cavalier drawings; half size in cabinet drawings; and any convenient length

for general oblique drawing. The advantage of an oblique drawing is that circles or curved surfaces can be viewed true size and shape in the front view. Circles and arcs viewed on the top or end will appear elliptical and must be drawn as an isometric circle would.

Materials used in pictorial sketching are the same as used in orthographic sketching with the exception of an isometric paper that has lines laid out at 30^{O} to the horizontal that makes isometric sketching easier.

SUGGESTED READING FOR THE STUDENT:

INFORMATION SHEET
ON
TECHNICAL SKETCHING

SUBJECT: Pictorial Sketches

INTRODUCTORY
INFORMATION:

A pictorial drawing is one in which the object is viewed in such a position that three faces appear in a single view. Pictorial drawings are excellent for showing an object in three dimensions and are frequently used to supplement work drawings or to assist untrained people in understanding views they cannot visualize in a regular print.

Pictorial drawings are used extensively in sales literature; assembly drawing; and in technical illustrations. One of the most common uses of pictorial drawings in the machinist field is the pictorial sketch which is a simple and quick method explaining or illustrating an idea.

It is to the advantage of a machinist to develop skills in making a pictorial sketch quickly and accurately. To develop these skills requires an understanding of the various types of pictorial drawings and techniques used in making a pictorial sketch.

GENERAL INFORMATION

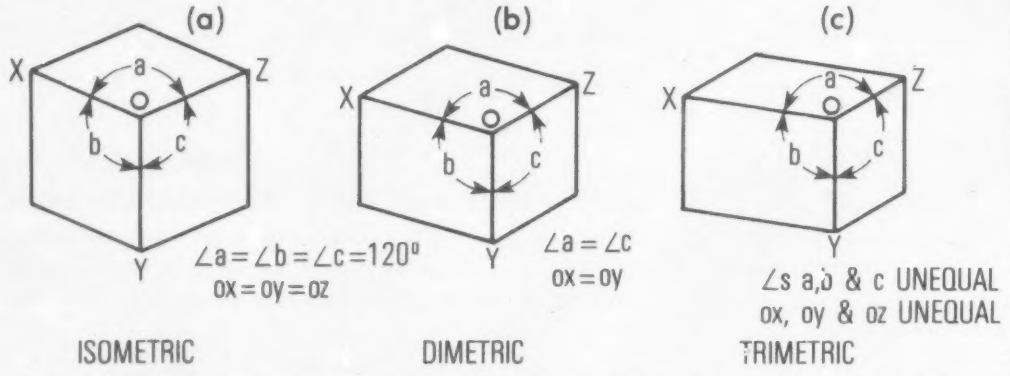
Types of Pictorial Drawing

Pictorial drawings are classified by the position the front face makes with the plane of projection and the angle and depth the receding lines project.

Pictorial drawings can be divided into three main types: (1) axonometric; (2) oblique, and (3) perspective. Each of these have different divisions which have their own characteristics. Although there are many applications for perspective drawings, they are not used frequently in the machinist trade.

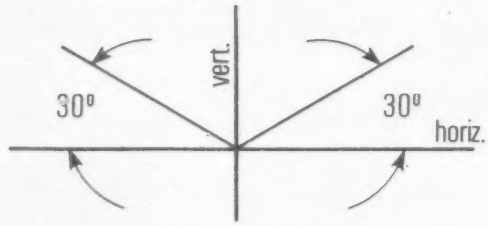
Axonometric drawings have the principal edges and surfaces inclined to the plane of projection causing the lengths of the lines, the sizes of the angles, and the general proportions of the object to vary. There are three classes of axonometric projections: (1) isometric, (2) dimetric, and (3) trimetric. Figure 1 shows the comparative differences among the three. We will concern ourself with the isometric view since it is the most common axonometric projection used.

FIGURE 1 AXONOMETRIC PROJECTION



Isometric drawings are positioned so that the principal edges or axes make equal angles with the plane of projection and therefore are foreshortened equally. See Figure 1. The principal edges form an axis referred to as the "Isometric Axis". The term isometric means "equal measure". The isometric axes are uniformly spaced at 120 degrees. The edges that project width and depth are drawn 30 degrees to the horizontal and the front edge, projecting height, will be vertical. See Figure 2.

FIGURE 2 ISOMETRIC AXIS



All lines parallel to the isometric axis are called "isometric lines" and are laid out along the isometric axes forming an isometric block as in Figure 3.

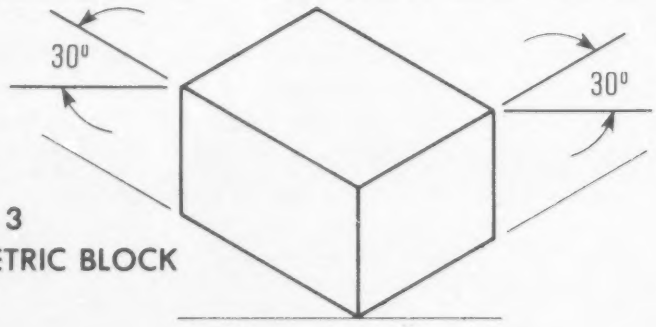
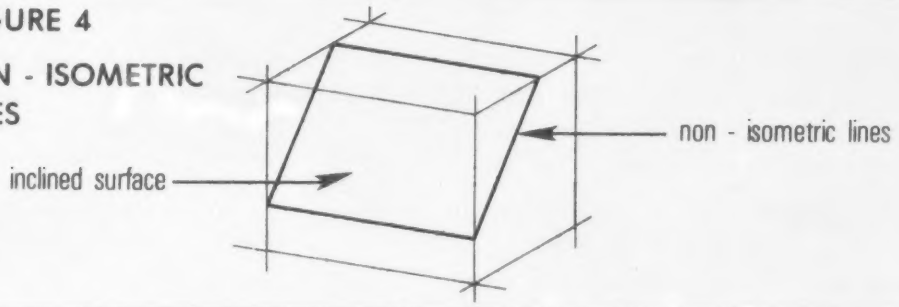


FIGURE 3
ISOMETRIC BLOCK

Edges that are not parallel to the isometric axis will not project true length and cannot be measured directly on the isometric axis. These lines are called "non-isometric lines". Non-isometric lines must have the end points located on the isometric lines first. The two points are then connected, forming a non-isometric line as shown in Figure 4.

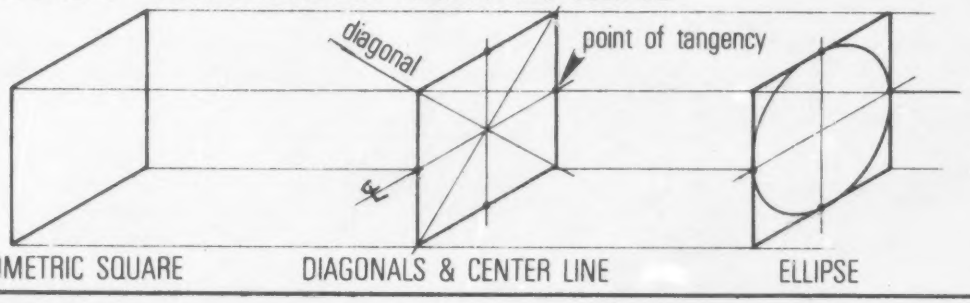
FIGURE 4

NON - ISOMETRIC LINES



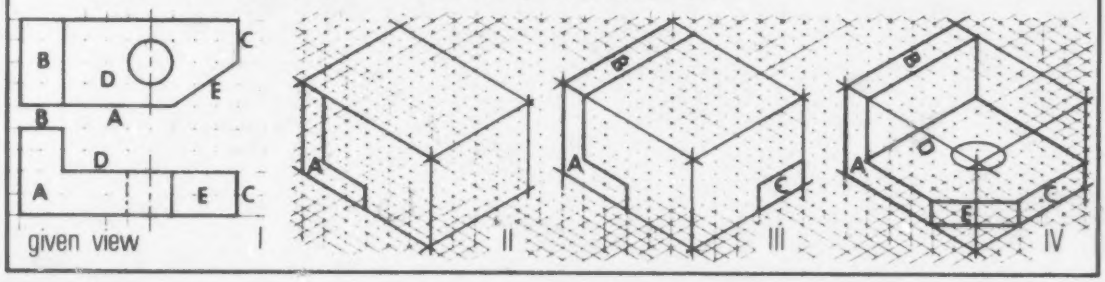
Circles in isometric will appear as ellipses. Arcs will appear as a part of an ellipse. The isometric circle is sketched somewhat the same as an orthographic circle, as an isometric square is sketched first with the diagonals of the square and center lines then drawn. This forms the boundaries and tangency points on the ellipse. The ellipse is then sketched in. See Figure 5.

FIGURE 5 SKETCHING AN ISOMETRIC ELLIPSE



One of the best aids in learning to sketch in isometric is the use of isometric paper. The lines of the paper form the axis of the isometric projection and permits the isometric grids to be used for sketching to size. Figure 6 illustrates the use of isometric paper and the steps in making an isometric sketch.

FIGURE 6 MAKING AN ISOMETRIC SKETCH

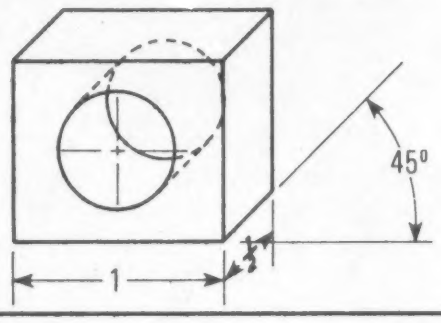


Oblique drawings are perhaps the easiest type of pictorial drawings to make. In the oblique drawing, one face of the object is parallel to the plane of projection and is viewed in true size and shape. The oblique drawing uses three axes as does the isometric drawing with this exception; two of the oblique axes are at right angle to each other and the third axis (receding axis) is projected at any convenient angle to the horzontal. All receding edges are drawn parallel.

There are three classifications of oblique projections: cabinet, cavalier, and general.

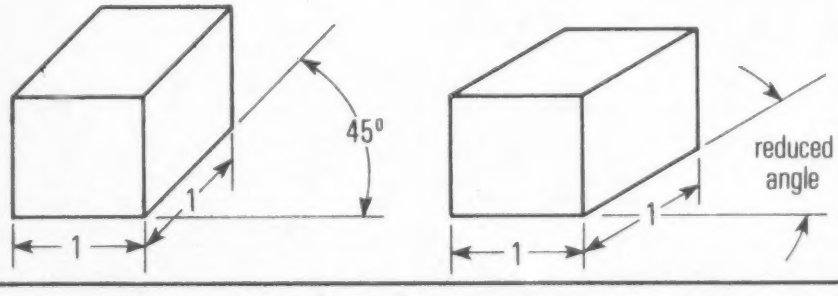
The cabinet oblique drawing normally has the receding lines drawn at a 45-degree angle. The scale or size of the receding lines is reduced to one-half, which gives a more natural appearance. See Figure 7.

FIGURE 7
CABINET



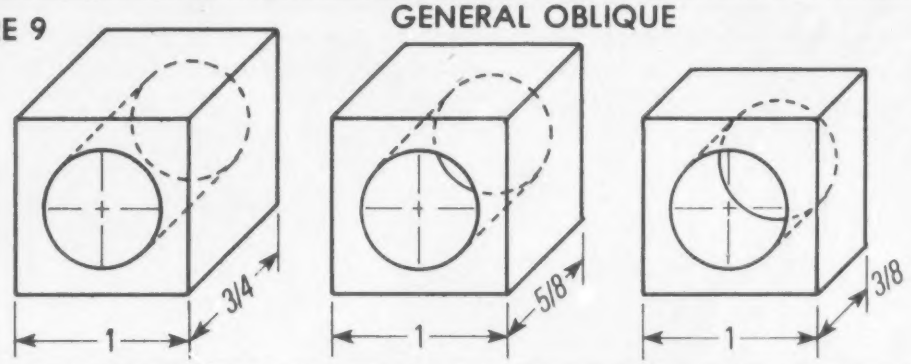
The cavalier oblique drawing is one in which the receding axis can be any angle but usually 30 or 45 degrees. The scale or size is the same on all axes, that is to say that all axes are drawn full size. This causes the object to appear distorted. However, distortion can be eliminated to some degree by reducing the angle of the receding axes. See Figure 8.

FIGURE 8
CAVALIER



The general oblique drawing is one in which the receding axis is usually between 30 and 60 degrees. The scale of the receding axis is variable and may vary from full size to three-eighths size, in order to obtain the most natural appearance of the object. See Figure 9.

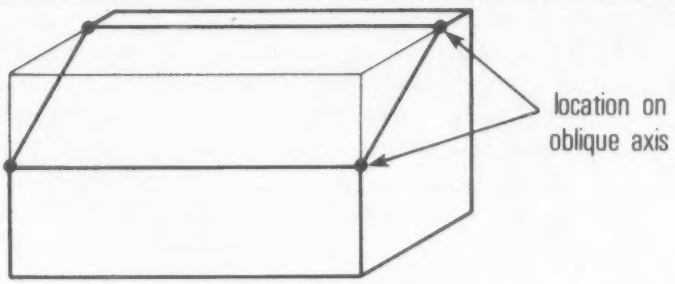
FIGURE 9 GENERAL OBLIQUE



Edges that are oblique or inclined must be laid out on the oblique axis in the same manner as they would be in an isometric drawing. The end points are located and the lines drawn, as in Figure 10.

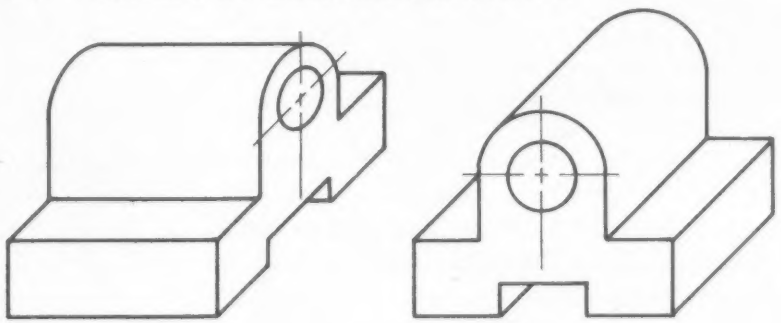
FIGURE 10

NON - PARALLEL LINES



The chief advantage of oblique drawing is the ease with which circular shapes can be drawn. In positioning the object, circular shapes will appear in true shape and size if viewed in the front face. Circular shapes that are not faced toward the front are viewed elliptical and distorted. Compare views in Figure 11.

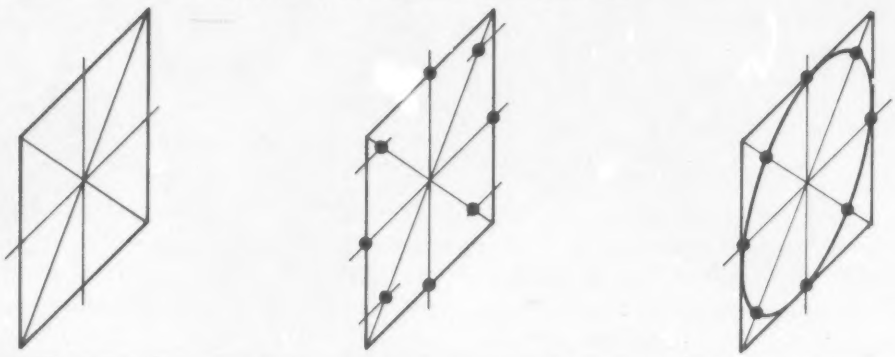
FIGURE 11 CIRCLES IN OBLIQUE DRAWINGS



When it is necessary to show a circular shape in a receding face, the same procedure as for drawing an isometric circle is used. An oblique square is sketched first. The

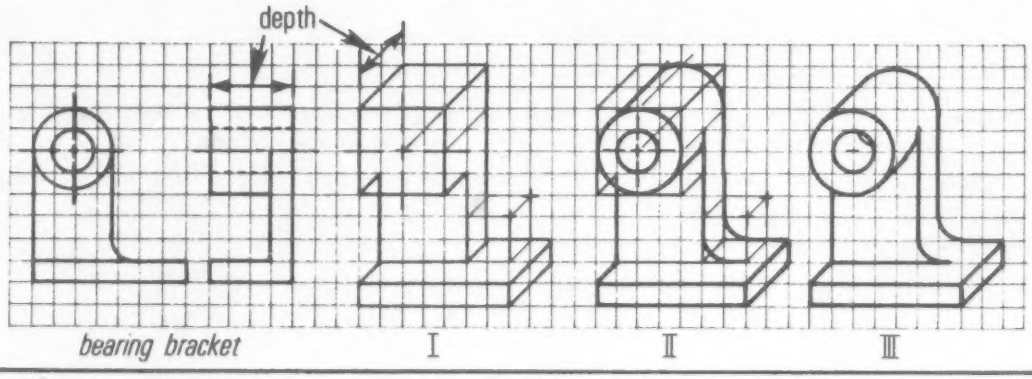
diagonals and center lines are drawn. The oblique square provides the boundaries for the circle and the center lines locate the points of tangency. See Figure 12.

FIGURE 12 SKETCHING AN OBLIQUE ELLIPSE



Oblique sketches can be made satisfactorily on ordinary coordinate (cross-section) paper. The lines drawn perpendicular to each other provide a guide for two of the oblique axes. Forty-five degree lines can be sketched easily by drawing diagonals through the squares. Dimensions are counted off on the grid of the paper. Figure 13 illustrates the procedure for making an oblique sketch.

FIGURE 13 MAKING AN OBLIQUE SKETCH

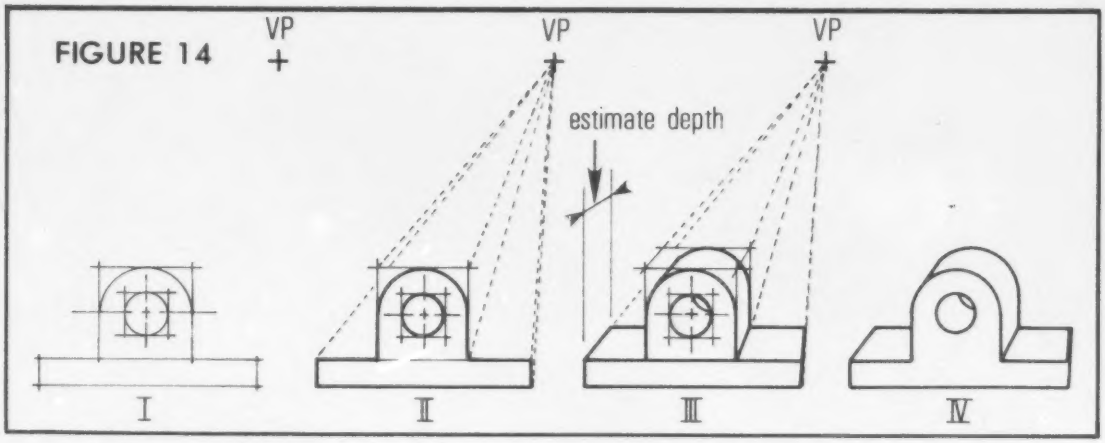


From a given orthographic sketch.

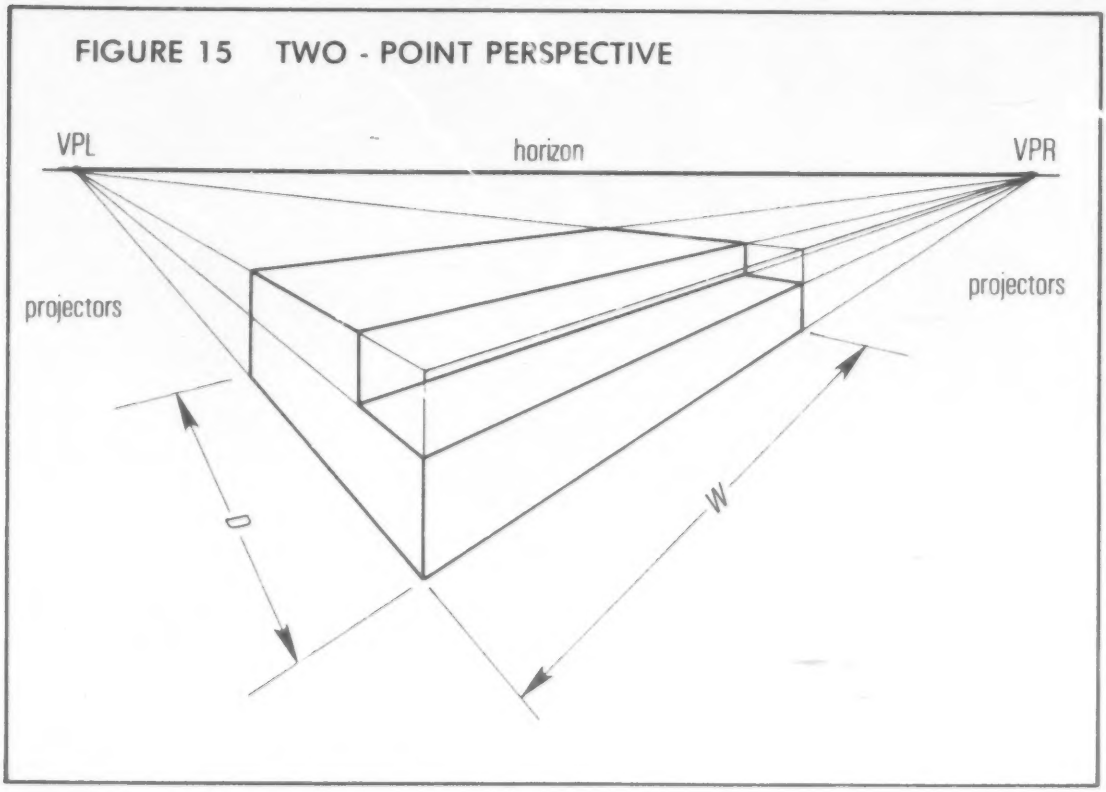
Perspective Drawings - The eye and camera are both constructed so that objects appear progressively smaller as they are viewed farther away. An example of this would be looking at the spacing between the rails of a railroad track or the height of fence posts. They all appear to disappear with distance. The point of disappearance is called the vanishing point.

Perspective drawings are developed on this principle. There are two types of perspective drawings: (1) parallel and (2) angular. In the parallel perspective (one-point) the front face is drawn as in the oblique drawing. Receding lines are projected

to a position where they become a point. This point is called the vanishing point (VP). See Figure 14.



In angular perspectives (two-point), which is the most true to life of all pictorial methods, two vanishing points are used. The vanishing points are located on the horizon (eye level). They are located to the left and right of the object. The corner edge of the object is drawn true size and the receding lines project to the vanishing points, labeled VPL (vanishing point left) and VPR (vanishing point right). The depth and width are laid out along the projectors.



ASSIGNMENT SHEET
ON
SKETCHING

II-C-2(AS)

SUBJECT: Pictorial Sketching

AIM: The student will be able to make an pictorial sketch correctly and accurately.

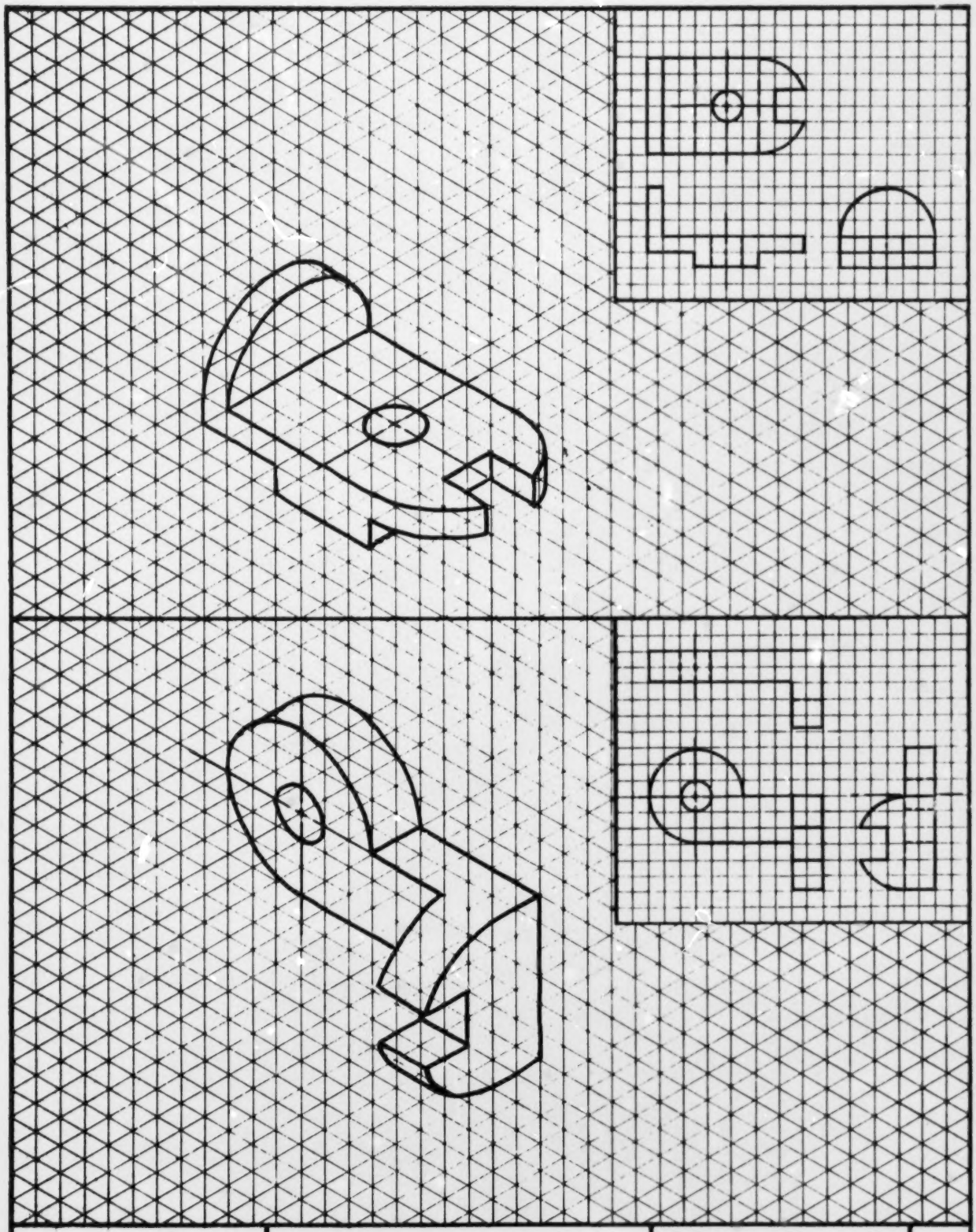
INTRODUCTORY INFORMATION: The term "Pictorial Drawing" refers to just what the term implies, a drawing that is viewed as if it were taken with a camera or as one would normally see an object, in three dimensions. Pictorial drawings are used in sales literature, assembly drawings, technical illustrations, or as a quick and simple way of explaining or conveying an idea to another person, especially a person who is not trained in reading prints.

Two types of pictorial presentations most commonly used by machinists are isometric and oblique. Information Sheet II-C-2(IS) explains the difference in each pictorial drawing and how the drawings are made. This assignment will provide the student with an opportunity to develop those skills necessary for the machinist to quickly and accurately sketch an object in pictorial representation.

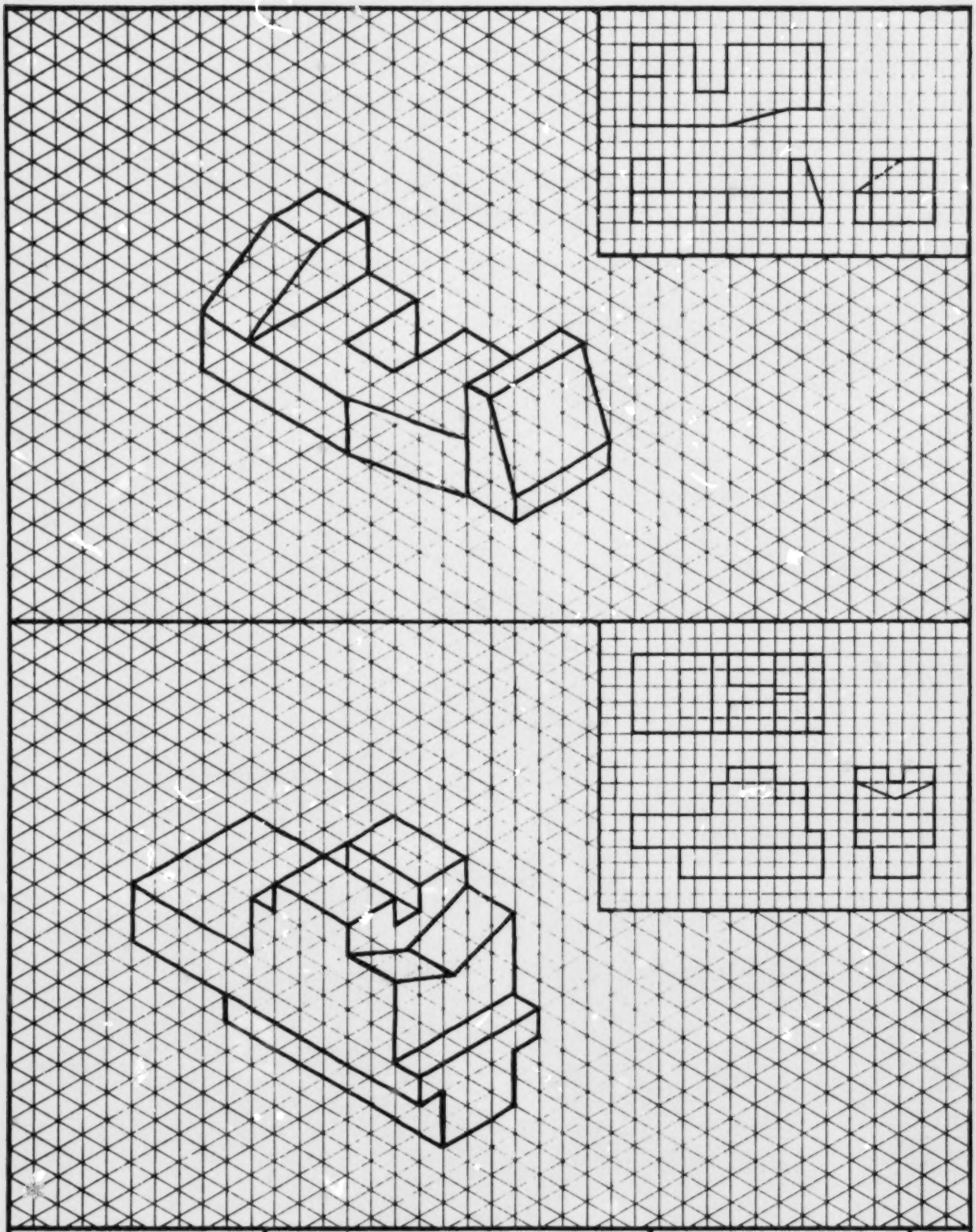
REFERENCE: Information Sheet II-C-2(IS) "Pictorial Sketches"

QUESTIONS OR PROBLEMS:

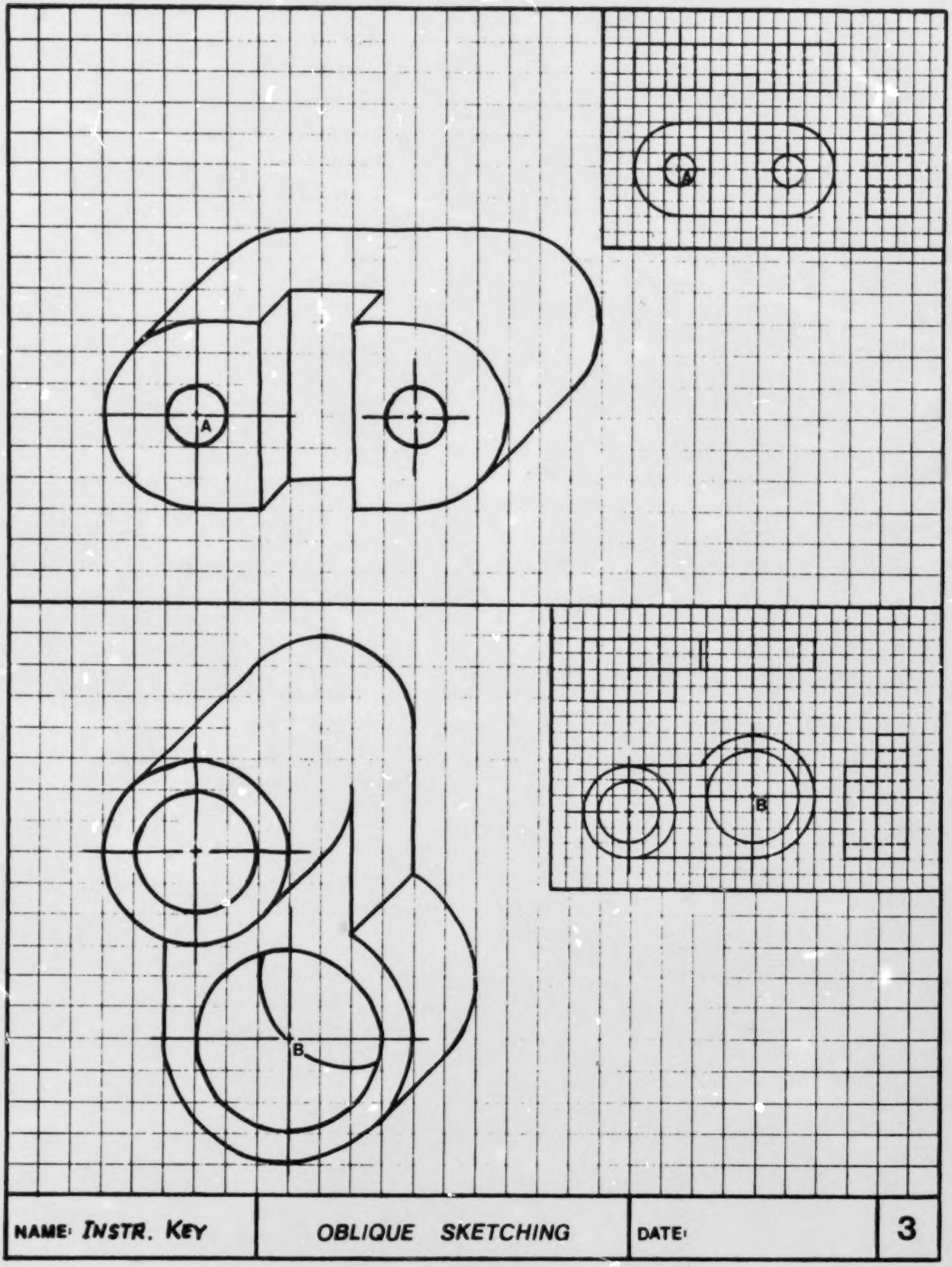
1. In problems 1 and 2, the student will study carefully the orthographic view in the right hand corner and complete the partially drawn isometric view. The student will use the orthographic grid for determining the size of the pictorial view. Show all construction lines and center lines.
2. In Assignment Sheet II-C-2(AS) problems 3 and 4, study the orthographic view in the upper right hand corner and complete the oblique sketch as required. In each problem a reference center is given to assist in the location of the view. For proportion to size, count the number of spaces in the orthographic view and count the spaces off on the oblique drawing. The size ratio is 1: 1: 1, and the receding angle is 45°. Leave construction lines and show center lines.



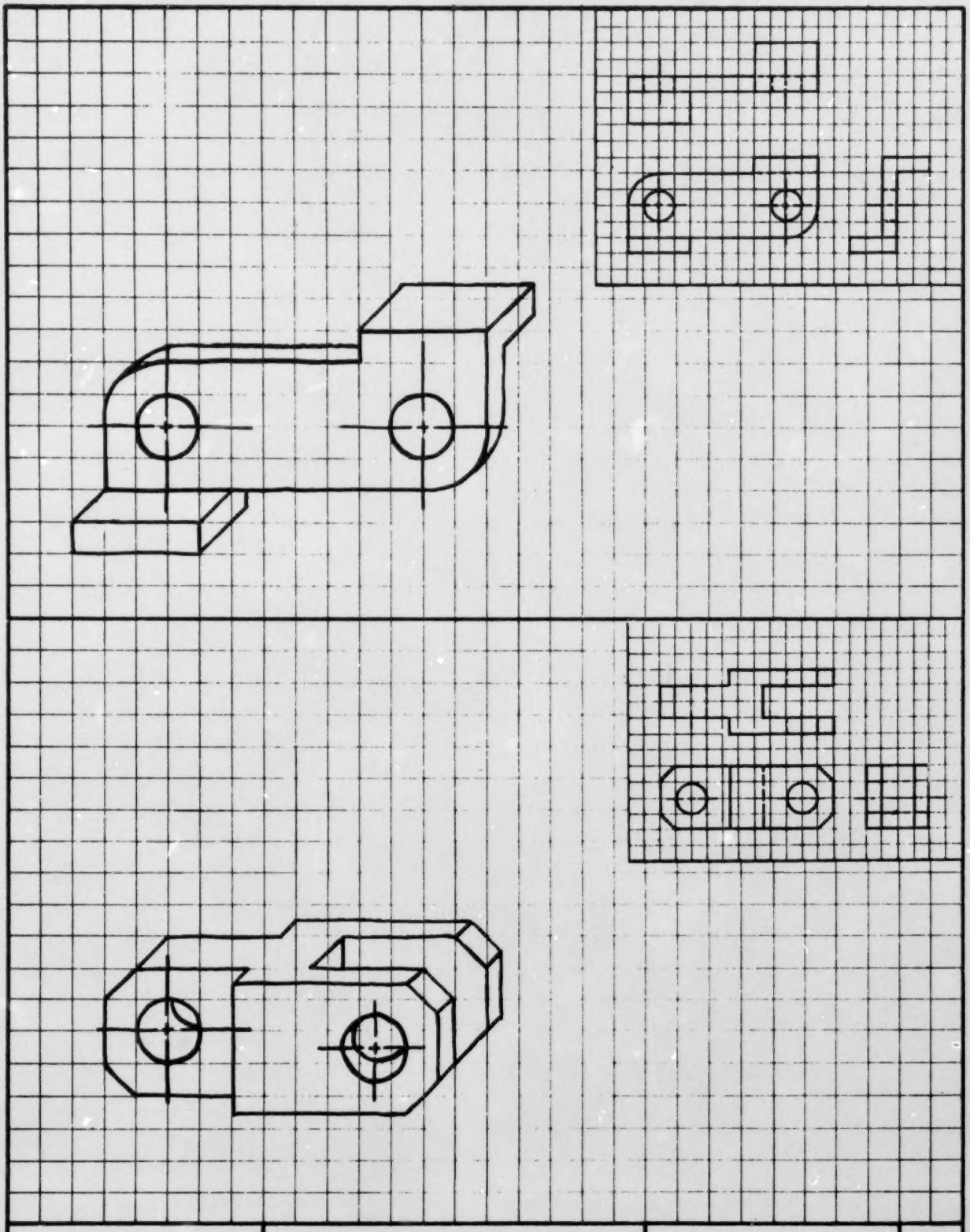
NAME: INSTR. KEY	ISOMETRIC SKETCHES	DATE:	1



NAME:	ISOMETRIC SKETCHES	DATE:	2



NAME: INSTR. KEY	OBLIQUE SKETCHING	DATE:	3



NAME: INSTR. KEY	OBLIQUE SKETCHING	DATE:	4

SIMPLE RECALL TEST
ON
PICTORIAL SKETCHING

NAME_____ DATE_____

DIRECTIONS: Read each statement carefully. When the answer has been selected which will complete the statement correctly, place the answer in the corresponding blank space in the right-hand column.

EXAMPLE:	1. Only two axes of a ____ drawing are foreshortened equally.	dimetric
1.	The principal axes of a ____ drawing make unequal angles with the plane of projection.	trimetric
2.	A circle viewed at an angle will appear as a/an ____.	ellipse
3.	The receding (depth) lines of a cabinet drawing are drawn at 45° and ____ scale.	½
4.	The front face of an oblique drawing is drawn ____ to the plane of projection.	parallel
5.	The projectors of a parallel perspective projects toward a ____ vanishing point.	single
6.	The edges of an isometric axis are spaced ____ degrees apart.	120
7.	The word "isometric" means ____.	equal measure
8.	The diminishing point of an object on the horizon is the ____.	vanishing point
9.	The advantage of ____ drawings is that circles, arcs, or irregular shapes can be viewed in the true size and shape in the front face.	oblique
10.	The receding edges of a cavalier oblique drawing are drawn to ____ size.	full
11.	Two axes of the isometric drawing are drawn ____ degrees to the horizontal.	30

12. Edges that are not parallel to the isometric axis are called ____ lines. — non-isometric

13. A drawing in which the depth axis is reduced to any scale in order to achieve proper proportion is the ____ oblique. — general

14. Sales illustrations are one of the common uses of a ____ drawing. — perspective

15. The depth axis of ____ oblique drawing is drawn to full scale. — cavalier

16. Lines parallel to the isometric axis are called ____ lines. — isometric

17. In an oblique drawing two of the axes are at a ____ angle to each other. — right

18. Two common perspective drawings are single point (parallel) and ____. — two-point

19. Isometric paper differs from cross-section (coordinate) paper in that it has two sets of lines that are drawn at ____ degree angles. — 30^{o}

20. Inclined lines of oblique drawings are drawn by locating their ____ points along the parallel axis and connecting the points. — end

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ON

PRINT READING

SUBJECT: Bolt Hole Patterns

INTRODUCTORY INFORMATION:

Accuracy and efficiency in print reading depend on one's ability to read and interpret conventional methods of conveying graphic information. One of the most important of these methods concerns machining operations such as, drilling, reaming, countersinking, boring, counterboring, and tapping holes.

GENERAL INFORMATION

In dimensioning holes, the diameter of the hole, the depth, operation and the number of holes of that size to be machined are indicated by a note on the print, as covered in Information Sheet II-B-3a(IS), "Abbreviations, Notes, and Symbols". Holes are located with reference to their center lines from a finished surface as a datum plane, as in Figure 1, or from an important center or center line as illustrated in Figure 2.

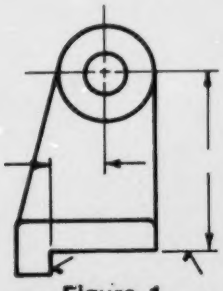

Figure 1

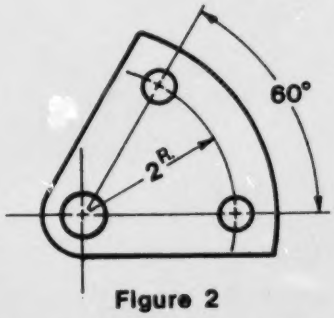

Figure 2

Holes equally spaced about a common center may be dimensioned by giving the diameter (diagonally) of the circle of centers, or as referred to, bolt circle, and are specified "equally spaced" on a note. See Figure 3.

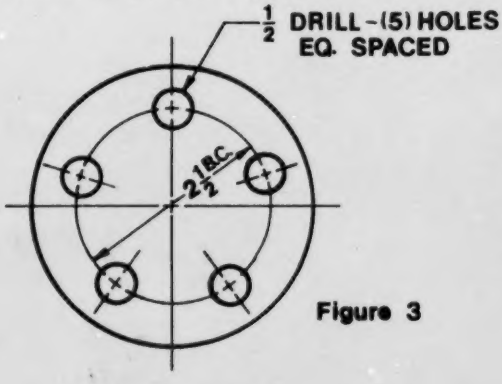

Figure 3

Holes unequally spaced are located by means of the bolt circle diameter and angular measurements referenced to only one of the center lines, as shown in Figure 4.

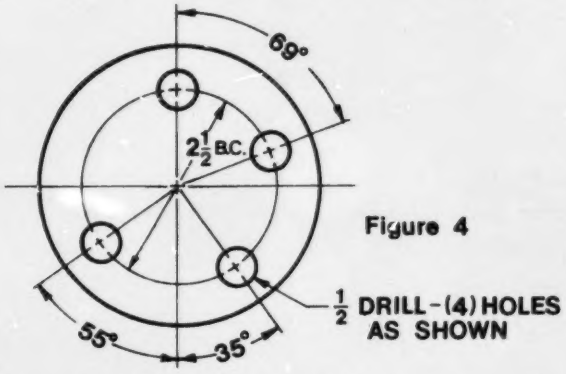

Figure 4

Where greater accuracy is required, coordinate dimensions are given as in Figure 5. The bolt circle is marked REF to indicate that it is to be used only as a reference dimension. The location dimensions are given in decimals with a tolerance.

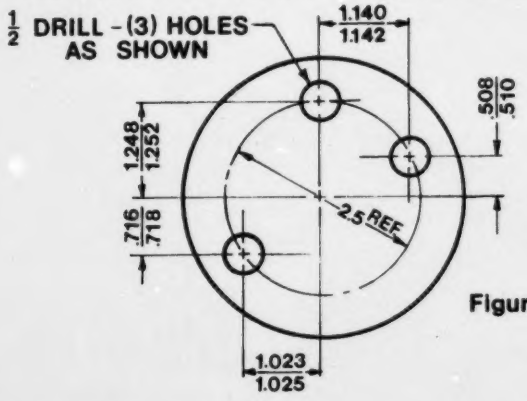

Figure 5

Frequently a note is used to give information concerning the hole size, number, location, and bolt circle diameter, as in figure 6.

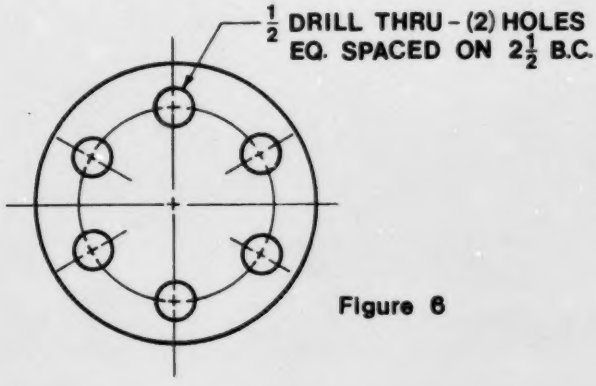

Figure 6

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ASSIGNMENT SHEET
ON
BOLT HOLE PATTERNS

II-D-1(AS)

NAME_____ DATE_____

DIRECTIONS: Study the drawing that corresponds to this assignment number. Fill in the blank with the information that will complete each statement correctly.

EXAMPLE: 1. The size rounds of the flange are ___. 1/16 R

1. The number of holes to be drilled are _____. 4
2. The maximum limit of each hole is _____. .314
3. The thread relief size is _____. 1/8 w x 1/8 d
4. The 3 - 1/2" diameter is called the _____. b bolt circle
5. Each hole is to be reamed and _____. counter bored
6. The flange diameter is _____. 4 3/8
7. The hole in the lower right quadrant is located _____ from the vertical center axis. 1.237 - 1.239
8. The thread calls for a class _____ fit. 2
9. The major diameter of the thread is _____. 2 1/2
10. The minimum size of the bored hole is _____. 1.750
11. The counter bore depth is _____. 5/16
12. The maximum distance from the flange face to the thread shoulder is _____. 1.005
13. The limits of the counter bored holes are _____. .437 - .439
14. The hole in the lower left quadrant is located _____ from the horizontal center axis. 1.003 - 1.005
15. The symbol on the thread shoulder and back of flange indicates that both are _____ surface. finished
16. The dimensioning technique used for locating the holes is called _____. coordinate
17. The letter "A" in the thread note refers to a/an _____ thread. external

18. The hole in the upper right quadrant is located ____ from the hole located on the verticle center axis. 1.644/1.646

19. The maximum distance between the hole in the lower right quadrant and the lower left quadrant is _____. 2.674

20. The minimum dimension between the center of the hole on the vertical center axis and the horizontal center axis is _____. 1.749

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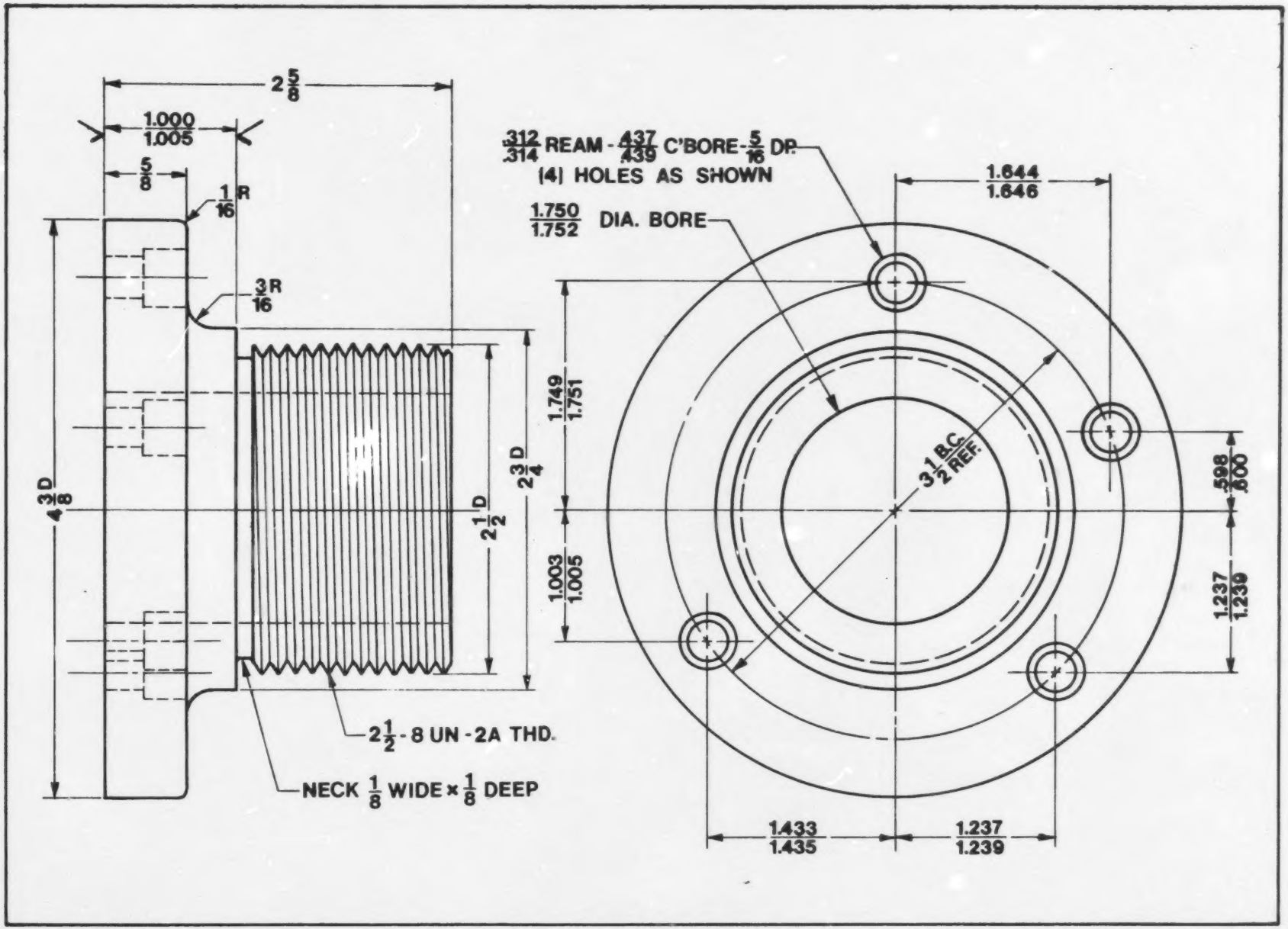

2 5/8
1.000
1.005
5/8
1/16 R
3/16 R
4 3/8 D
2 3/4 D
2 1/2 D
2 1/2 - 8 UN - 2A THD.
NECK 1/8 WIDE × 1/8 DEEP
.312
.314 REAM - .437
.439 C'BORE - 5/16 DP.
(4) HOLES AS SHOWN
1.750
1.752 DIA. BORE
1.644
1.646
1.749
1.751
1.003
1.005
3 1/2 B.C.
REF.
.598
.600
1.237
1.239
1.433
1.435
1.237
1.239

ON

PRINT READING

SUBJECT: Gears

INTRODUCTORY INFORMATION:

Gears are used to transmit motion, rotating or reciprocating, from one machine part to another by successively engaging the teeth of the gears. They are used in place of belt drives and other types of frictional drives when the exact speed ratio or power transmission must be maintained. Gears may be used to change the speed of a driven shaft, thus increasing or decreasing the torque of the driven member.

A basic knowledge of gears is essential to the machinist because of the universal use of gears in industry and the existence of standard practices for the representation of gears on prints.

The method by which gears are represented on a print is based on the following factors:

1. The type of gear and its features
2. The different parts of gears and their names
3. The formulas used for computing the dimensions of the parts of the gear.

GENERAL INFORMATION

Principles of Gearing

The basis of all gearing consists of the imparting of rotary motion by one part to another. Motion can be imparted from one shaft to another parallel shaft by friction, as in Figure 1, or by belt, as on a belt driven drill press. This type of drive is subject to slipping and excessive pressure, and therefore is less effective. This ineffectiveness can be overcome by the use of teeth on one cylinder interlocking with teeth on the second cylinder, as in Figure 2. The interlocking teeth provide a "grabbing" feature by which one gear can drive another gear effectively without loss of power transmission or speed ratio. This mechanical operation is known as gearing. This principle of imparting rotary motion from one part to another by means of interlocking teeth is basic for all methods of gearing, regardless of type of gear.

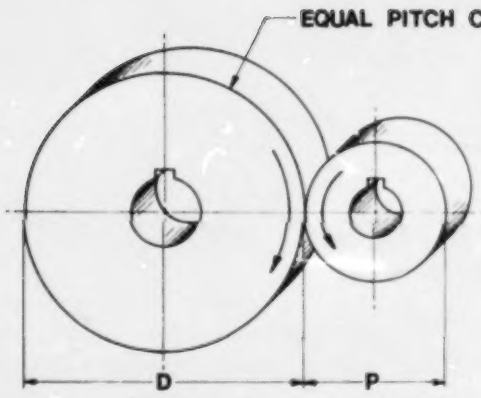


Figure 1
(Friction Drive)

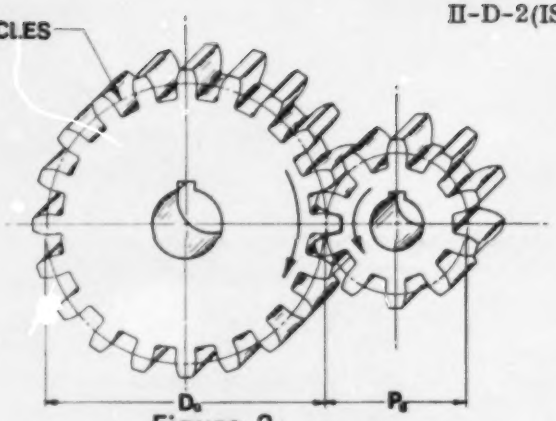


Figure 2
(Gear Drive)

Types of Gears

Gears may be classified according to the position of the shafts they connect. Parallel shafts, for example, may be connected by spur gears, helical gears, or herringbone gears, as in Figure 3.

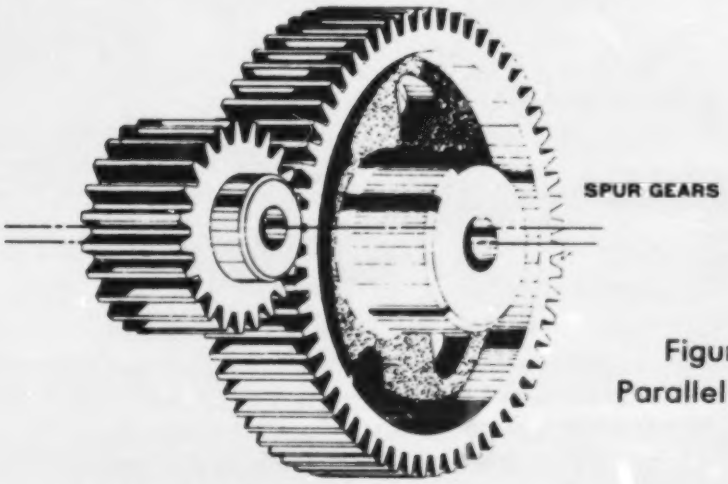


Figure 3
Parallel Shafts

Intersecting shafts may be connected by bevel gears having either straight, skew, or spiral teeth. See Figure 4.

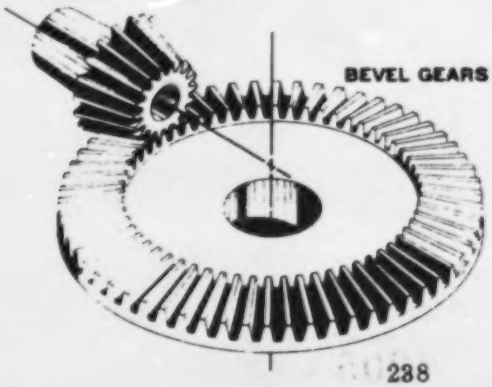


Figure 4
Intersecting Shafts

Non-parallel, non-intersecting shafts may be connected by hypoid gears, used in automobile drives, or a worm and worm gear. See Figure 5.

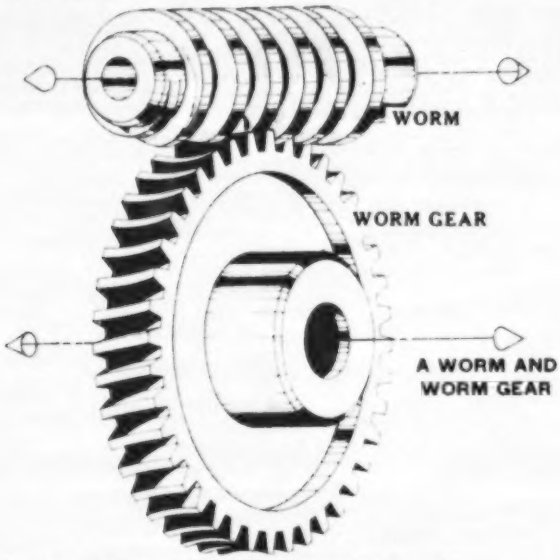


Figure 5

C. Non-Parallel, Non-Intersecting Shafts

A spur gear meshed with a rack will convert rotary to a reciprocating motion, as in Figure 6. This system is common to the lathe, surface grinder, and milling machine.

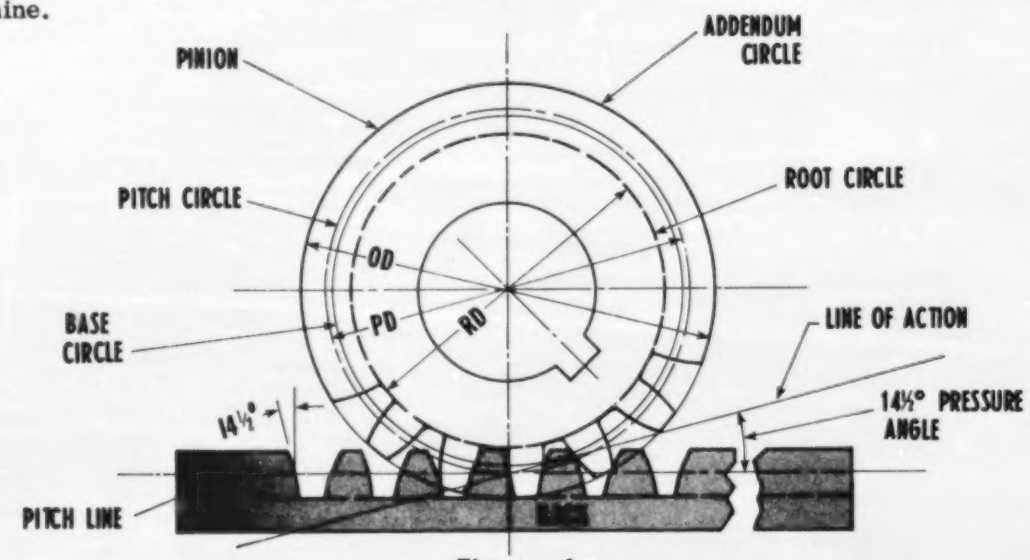


Figure 6

RACK AND PINION WITH 14½° COMPOSITE SPUR TEETH

Because the design of gears is a complex problem, only the straight-tooth spur gear will be discussed.

Parts of the Gear

When two gears are meshed, as illustrated in Figure 7, the imaginary circle formed by the points of contact between the gears is called the pitch circle. The pitch circle is located about halfway between the top and bottom of the gear teeth.

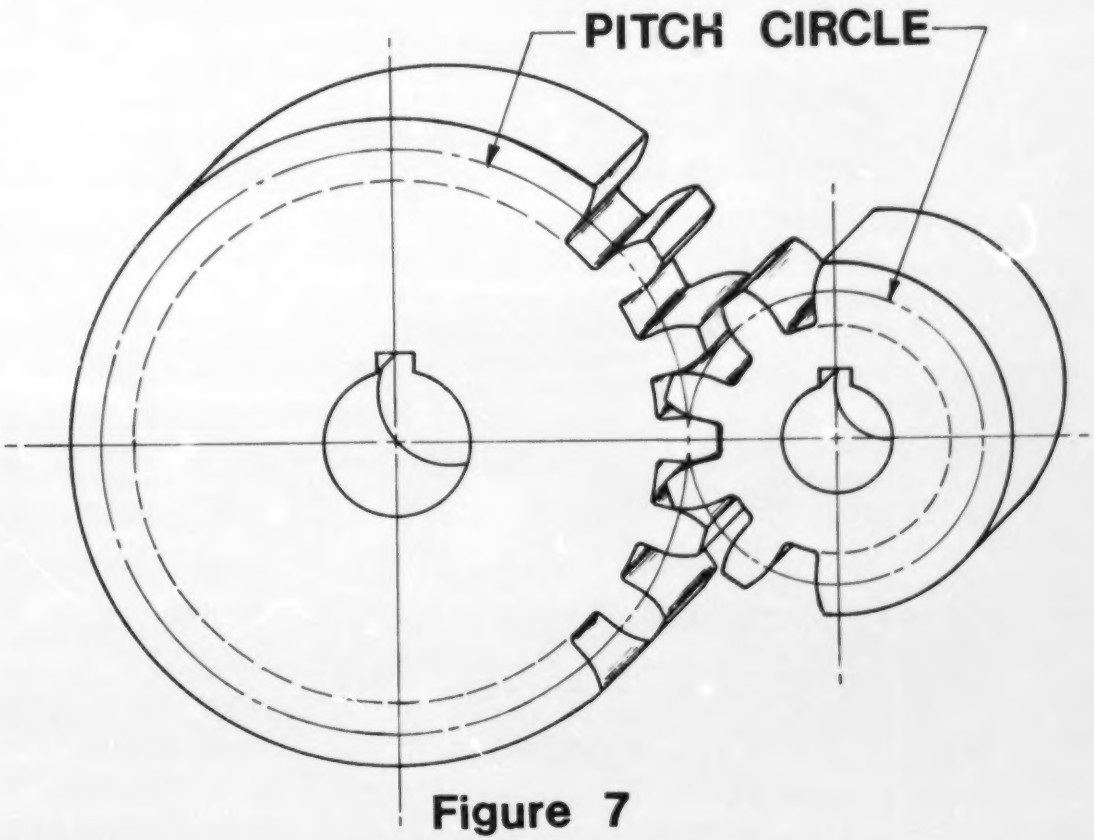
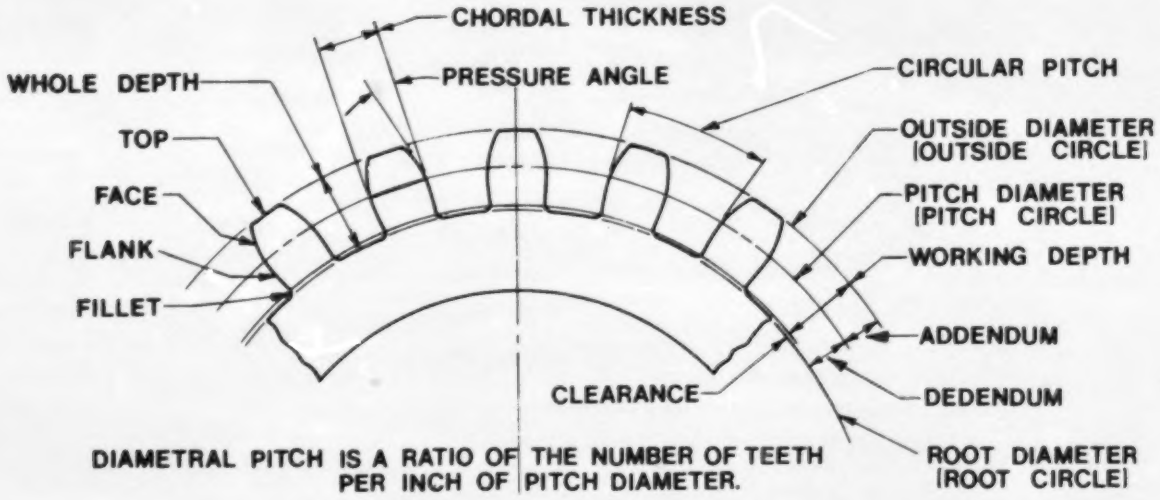


Figure 7
SPUR GEARS

The pitch circle is only one of many important parts of the gear, as illustrated in Figure 8. It is important that the machinist know the terms and definitions of gearing as a part of technical communication, as well as the math formulas used in making calculations for cutting gears.



GEAR NOMENCLATURE
Figure 8

Gear Terminology

Proportions and shapes of gear teeth are well standardized. The terms defined below and illustrated in Figure 8 are common to all gears.

Addendum (A) - The height of the tooth above the pitch circle.

Chordal Thickness (CT) - The thickness of the tooth measured at the pitch circle. Dimension obtained when a gear-tooth caliper is used to measure the thickness at the pitch circle.

Circular Pitch (CP) - The distance from a point on one tooth to a corresponding point on the next tooth measured on the pitch circle.

Clearance (C) - The distance between the top of a tooth from a mating gear to the bottom of the tooth space of a gear being mated.

Dedendum (D) - The radial distance from the pitch circle to the bottom of the tooth space. The dedendum is equal to the addendum plus the clearance.

Diametral Pitch (DP) - The number of teeth in a gear to each inch of pitch

Outside Diameter (OD) - the overall diameter of the gear blank.

Pitch Circle (PC) - The imaginary circle of a gear which could be moved by friction alone if it were a simple cylinder. The imaginary circle located approximately halfway between the tops and roots of the teeth.

Pitch Diameter (PD) - The diameter of the pitch circle.

Pressure Angle - The angle between the line of action and the line tangent to the pitch circle.

Rack - A gear with teeth spaced along a straight line and suitable for straightline motion.

Ratio of Gearing - Ratio of the numbers of teeth on mating gears. For example: If the ratio is "2 to 1", this usually means the smaller gear makes two revolutions to one revolution of the larger mating gear.

Root Circle - The circle formed by the bottom of the tooth spaces.

Root Diameter - The diameter of the root circle.

Whole Depth (WD_2) - The total depth of a tooth space, equal to addendum plus dedendum or working depth plus clearance.

Working Depth (WD_1) - The depth of engagement of two gears or the sum of their addendums.

Formulas for Computing Spur Gear Dimensions

There are rules and mathematical formulas used for calculating the dimensions of any part of a spur gear. The basic data always indicated on gear drawings are the number of teeth and the diametral pitch. From these specifications, any dimension can be found by substituting the appropriate values in the formula. The following table contains the basic formulas used to calculate principal characteristics of spur gears.

FORMULAS FOR CALCULATING GEAR DIMENSIONS

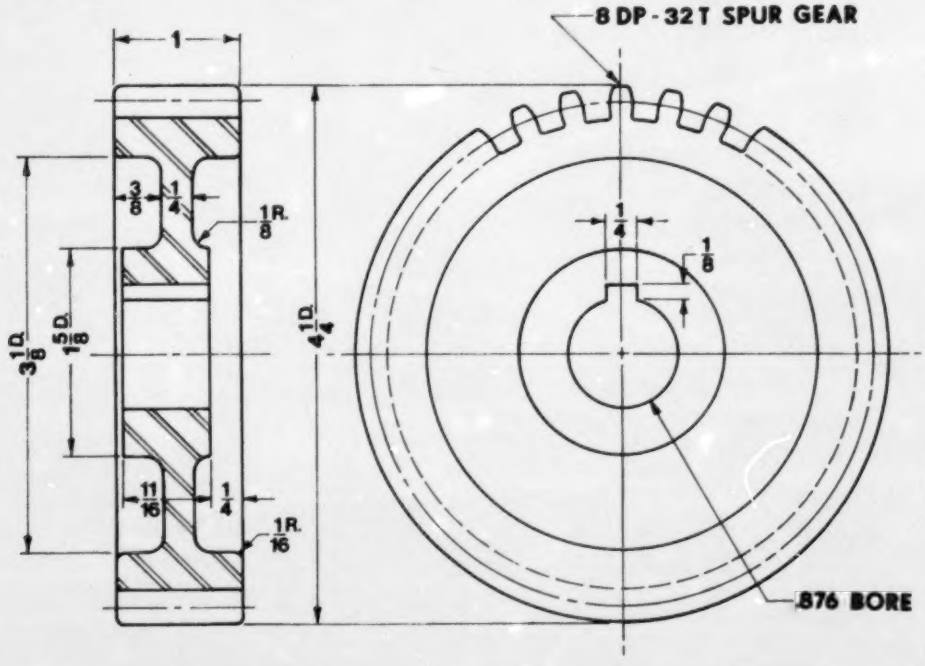
FORMULAS TO FIND:		EXAMPLES:
OUTSIDE DIAMETER (OD)	$= \frac{\text{NO. OF TEETH} + 2}{\text{DIAMETRAL PITCH}}$	$\frac{20T + 2}{10\ DP} = 2.200$
PITCH DIAMETER (PD)	$= \frac{\text{NO. OF TEETH}}{\text{DIAMETRAL PITCH}}$	$\frac{20T}{10\ DP} = 2.000$
WORKING DEPTH (WD_1)	$= \frac{2}{\text{DIAMETRAL PITCH}}$	$\frac{2}{10\ DP} = .200$
WHOLE DEPTH (WD_2)	$= \frac{2.157}{\text{DIAMETRAL PITCH}}$	$\frac{2.157}{10\ DP} = .257$
ROOT CIRCLE DIAMETER	$= OD - 2\ WD_2$	$2.200 - 2(.2157) = 1.7686$
CLEARANCE (C)	$= \frac{.157}{\text{DIAMETRAL PITCH}}$	$\frac{.157}{10\ DP} = .0157$
CIRCULAR PITCH (CP)	$= \frac{3.1416}{\text{DIAMETRAL PITCH}}$	$\frac{3.1416}{10\ DP} = .314$
NUMBER OF TEETH (T)	$= OD \times DP - 2$	$2.200 \times 10 - 2 = 20$
ADDENDUM (A)	$= \frac{1}{\text{DIAMETRAL PITCH}}$	$\frac{1}{10\ DP}$ .100
CHORDAL THICKNESS (CT)	$= \frac{\text{CIRCULAR PITCH}}{2}$	$\frac{.314}{2} = .157$

ASSIGNMENT SHEET
ON
GEARS

II-D-2(AS)

NAME_____ DATE_____

Directions: Study the print given and fill in each blank with the correct answer. Refer to the formulas given in Information Sheet II-D-2(IS) for computing the answer.



1.	Pitch diameter of gear	4.000"
2.	Diametral pitch	8
3.	Outside diameter	4.250"
4.	Circular pitch	8
5.	Number of teeth	32
6.	Whole depth	.2696
7.	Diameter of hub	1 5/8"
8.	Keyway size	1/8" x 1/4"
9.	Addendum	.125"
10.	Gear face size	1.000"
11.	Bore diameter	1.000"
12.	Length of hub	11/16"
13.	Working depth of tooth	.250"
14.	Chordal thickness (tooth)	.393"

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SUBJECT: Assembly Drawings

INTRODUCTORY INFORMATION:

Machinist work is not limited to reading and interpreting work drawings only. Frequently it is necessary to refer to drawings that do not deal with such information as what size to machine a part, but the relationship of a part with other component parts when they are assembled together. In addition, the machinist may be called upon to install a machine, assist in planning the setup of machine tools in the plant, or in the overall maintenance and repair of equipment. These situations require the ability to read special drawings referred to as "assembly drawings".

GENERAL INFORMATION:

Purpose

The main purpose of an assembly drawing is to provide information concerning the relationship of individual parts of a machine, structure or multipart tool or object. They may be drawings that show how individual parts assemble together; the overall appearance of the part as a whole; provide installation dimensions and directions for maintenance and operation. Also assembly drawings are used in the advertising of a tool or machine.

Types

Assembly drawings will vary according to their use. They may be drawn either as a pictorial or orthographic representation. The following are types of orthographic assembly drawings:

General Assembly drawings serve primarily to show how individual parts of a machine or multipart object fit together. All of the parts are drawn in their functional position. This type drawing is useful in the assembly phase of machines. Each individual part is identified by either a number or reference letter enclosed in a circle with a leader line pointing to the part, (A), (2), and is used in conjunction with details and a bill of materials. Figure 1 illustrates an example of a general assembly drawing.

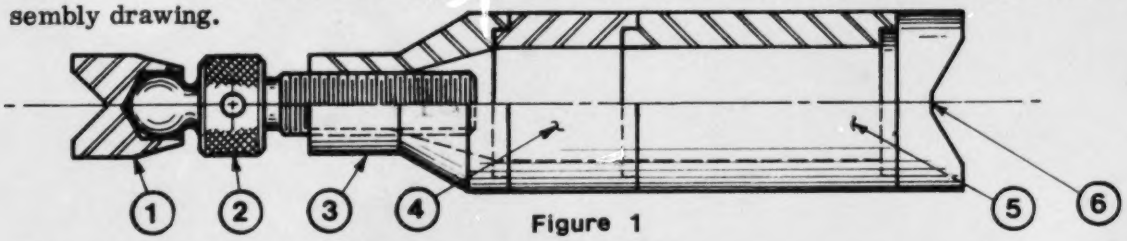


Figure 1

Work Drawing Assembly drawings are used for parts or objects that are not very complicated. The drawing gives complete information for producing the total assembled part by providing the necessary views required, including dimensions, notes, and symbols as required to produce the part, and the assembly of all parts. Each part is referenced by letter or number, as discussed previously, to the parts list or bill of materials, as shown in Figure 2.

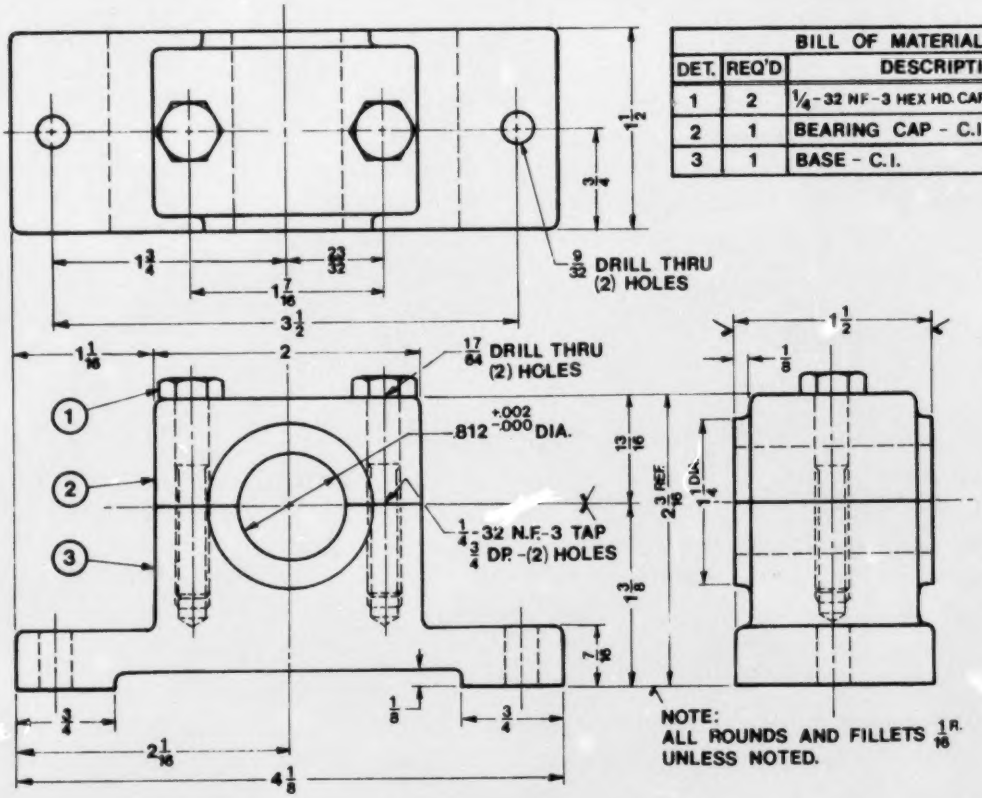

BILL OF MATERIAL
DET. | REQ'D | DESCRIPTION
1 | 2 | 1/4-32 NF-3 HEX HD. CAP SCW. x 1 1/2 LG.
2 | 1 | BEARING CAP - C.I.
3 | 1 | BASE - C.I.
9/32 DRILL THRU (2) HOLES
17/64 DRILL THRU (2) HOLES
.812 +.002 -.000 DIA.
1/4-32 N.F.-3 TAP 3/4 DP. -(2) HOLES
NOTE: ALL ROUNDS AND FILLETS 1/16 R. UNLESS NOTED.

Figure 2

Installation Assemblies are made specifically to show how a machine or structure is installed or erected. This type of drawing is referred to as an outline assembly, because only the outlines and relationships of exterior surfaces are shown. See Figure 3.

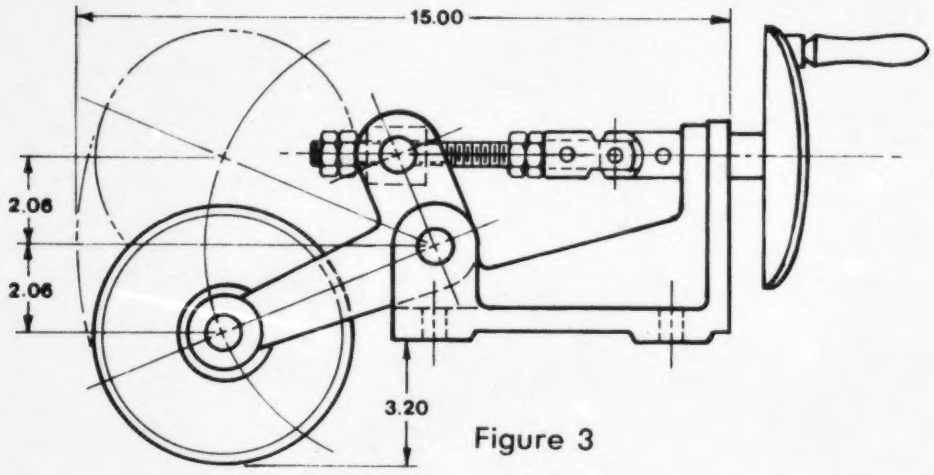


Figure 3

Dimensions given on the print are normally given to indicate the amount of spaces needed to install it properly. Frequently, a machine will have a large number of dimensions, and placing the dimensions on the drawing becomes complex. In such cases, the dimensions are substituted by letters or numbers that refer to the actual dimensions located in the reference table, as in Figure 4.

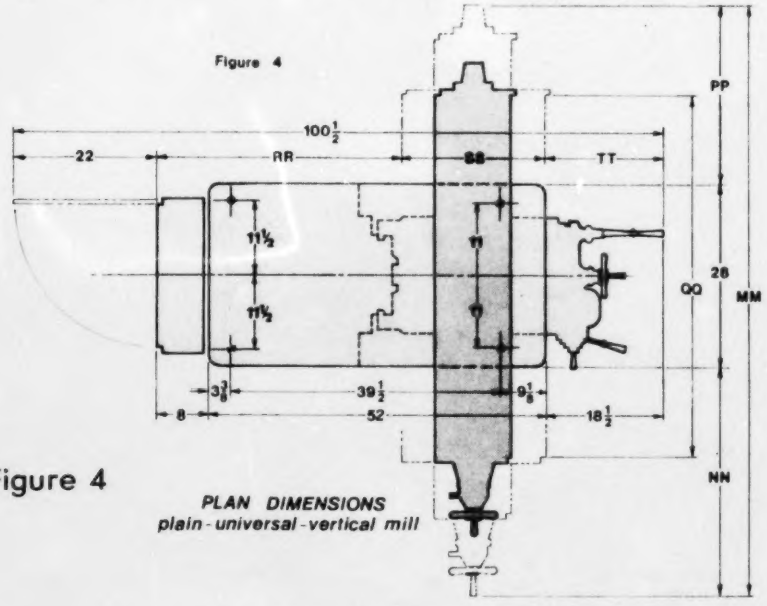


Figure 4

Machine	MM	NN	PP	QQ	RR	SS	TT
205 S-12	101	40	33	56	38¼	22	18¼
207 S-12	114	46½	39½	62½	38¼	24	16¼

Pictorial Assembly drawings may be classified into two common types. One is the cutaway drawing as shown in Figure 5.

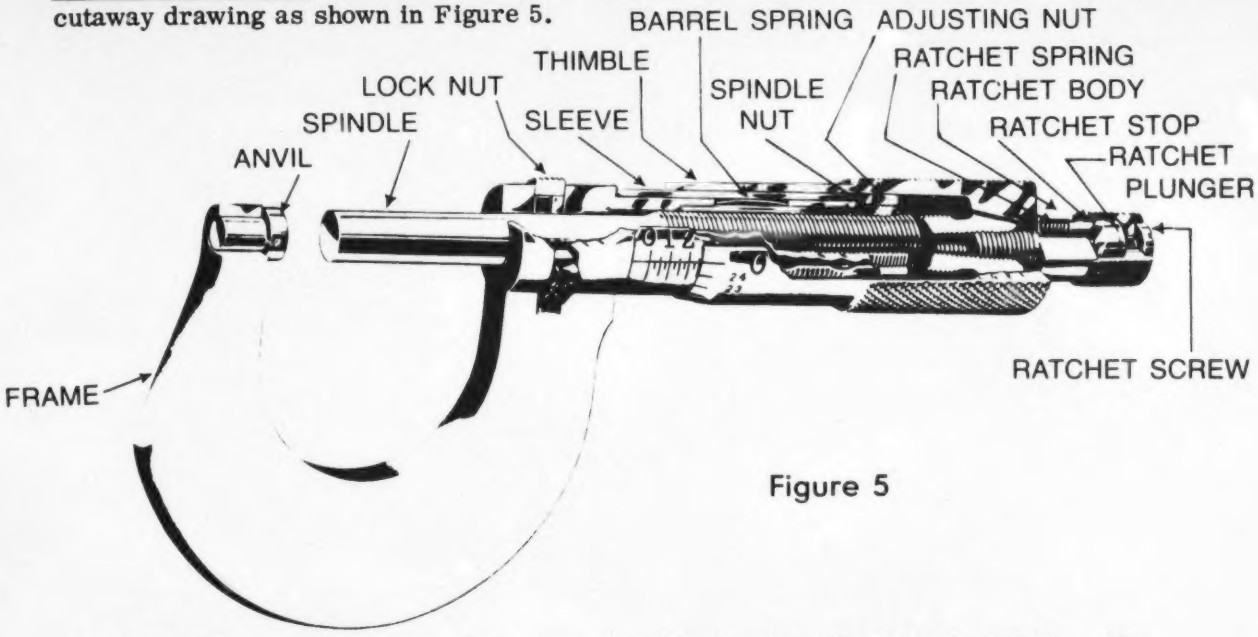
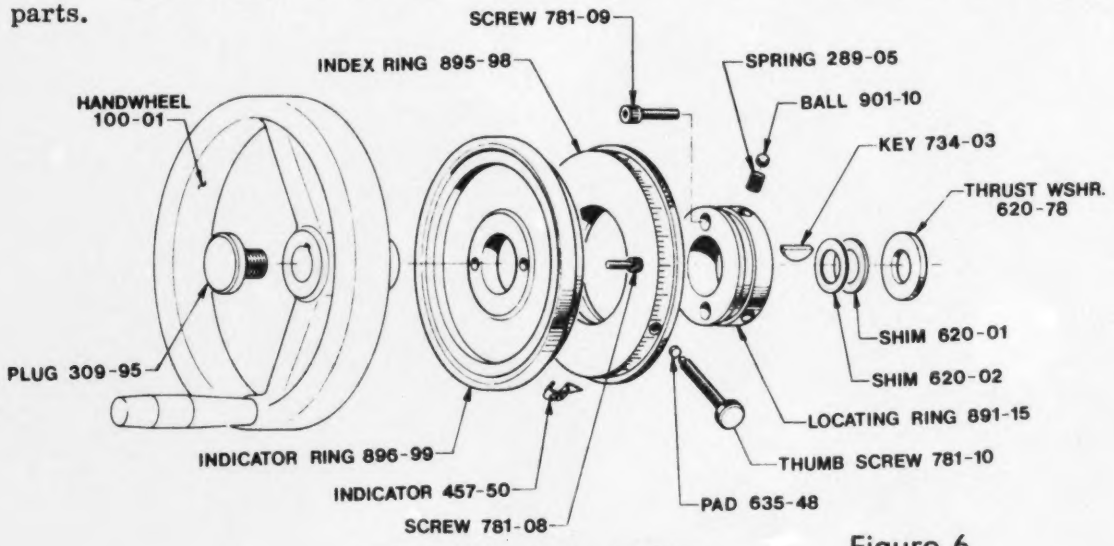


Figure 5

The part is drawn as a sectional view in order to show the interior details. The drawing is shaded much like a photograph and is commonly referred to as a production illustration. It is used primarily in sales materials and catalogs.

A second means of presenting a pictorial assembly is by use of an exploded drawing, as in Figure 6. Each part is drawn pictorially with the location and order of assembly shown. Each part is identified by name or a number which is referenced to a parts listing. This type of drawing is used in repair manuals for ordering repair parts, and frequently accompanies a machine to assist in assembly and identifying parts.



LONGITUDINAL DIAL ASSEMBLY
ENGINE LATHE

Figure 6

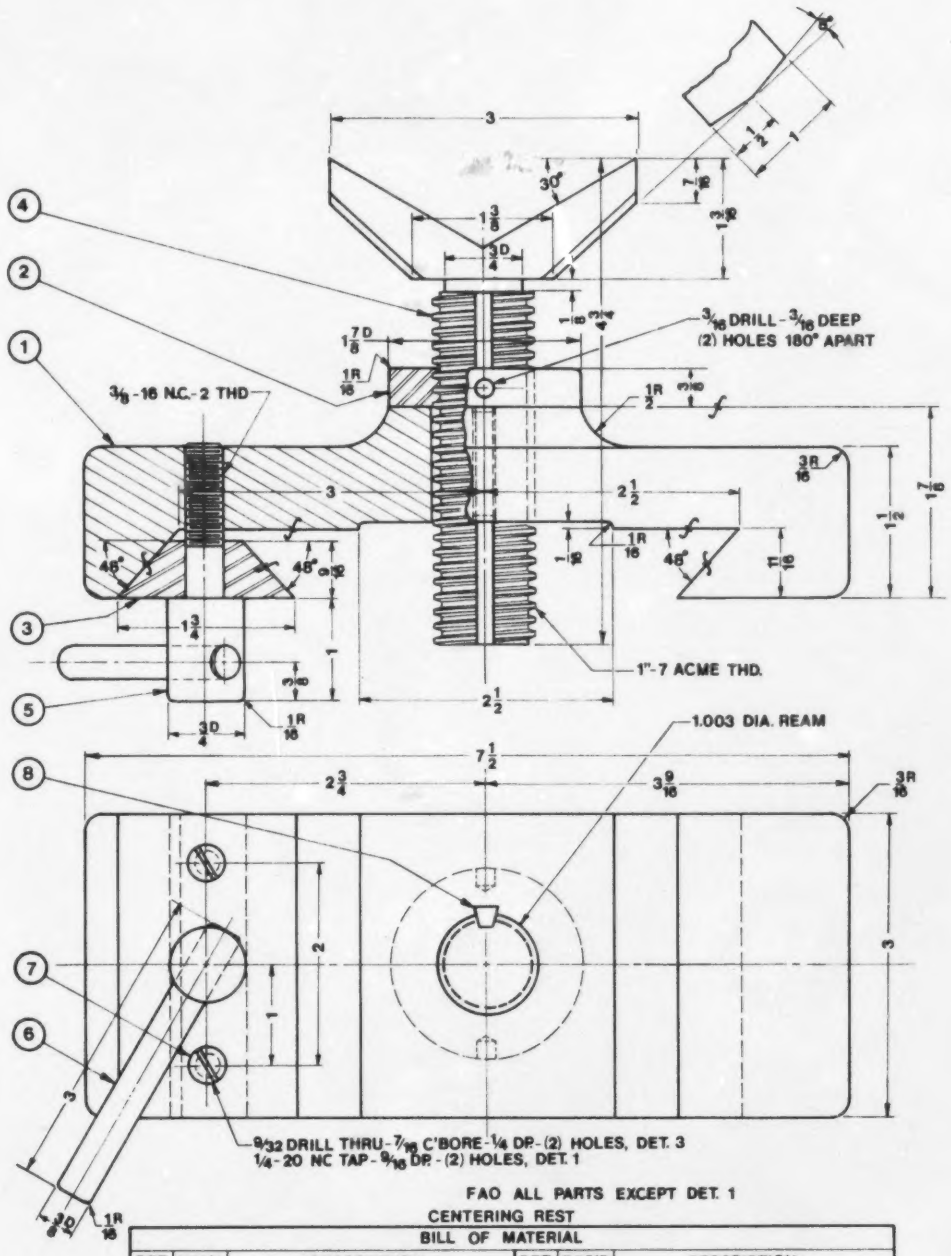
ASSIGNMENT SHEET
ON
ASSEMBLY DRAWINGS

II-D-3(AS)
Key

NAME_____ DATE_____

Directions: Read the drawing that corresponds to this assignment number. Write the correct information in the blank space to complete each statement.

1. The O.D. of the adjusting nut is _____. 1 7/8"
2. The included angle of the V-block of the rest is _____. 120°
3. The overall size of the clamp is _____. 9/16" x 1 3/4" x 3"
4. The clamp handle is made of _____. SAE 1020
5. There are three fillet sizes in detail #1, 1/16", 3/16", and _____. 1/2"
6. The depth of (2) 3/16" diameter holes is _____. 3/16"
7. The depth of the dovetail in the base is _____. 11/16"
8. The total length of detail #2 is _____. 4 3/4"
9. The distance between the fillister head screws is _____. 2"
10. The internal angles of the dovetail are _____. 48°
11. The length of the reamed hole is _____. 1 1/8"
12. The length of the ACME thread is _____. 3 7/16"
13. The base height of the centering rest is _____. 1 7/8"
14. The locating dimension for the dovetail in the base is _____. 2 1/2"
15. The thread machined on the clamp screw is _____. 3/8-16 UNC-2
16. The diameter of the center hole in the base is _____. 1.003"
17. The ACME thread relief is _____ in diameter. 3/4"
18. The maximum overall assembled length of this fixture is _____. 8 15/16"
19. The base has _____ tapped holes. 3
20. The minimum sized material required to make detail #2 is _____. 9/16" x 1 3/4" x 3"



BILL OF MATERIAL

DET.	REQ'D	DESCRIPTION	DET.	REQ'D	DESCRIPTION
1	1	BASE - C.I.	5	1	CLAMP SCREW - SAE 1020
2	1	REST - SAE 1020	6	1	CLAMP HANDLE - SAE 1020
3	1	CLAMP - SAE 1020	7	2	1/4-20 x 1" LG. FIL. HD. CAP SCR.
4	1	ADJUSTING NUT - SAE 1020	8	1	KEY - SAE 1040

GLOSSARY

Abrasive: Crushed sharp crystals of grinding material used in the form of grinding wheels, polishing cloth, and lapping powder.

Acme thread: A thread system used extensively for feed mechanisms. It is between a square thread and V-thread. The thread angle is 29°.

Acute angle: An angle less than 90°.

Align: To set mechanisms or machines in proper relation to each other.

Allowance: An intentional difference in dimensions between mating parts.

Alphabet of Lines: The type and weight of lines used in drafting.

Angle: The geometrical figure formed by two intersecting straight lines; also, the space between the intersecting straight lines.

Anneal: To heat a metal piece to its critical temperature and then allow it to cool slowly, thus reducing brittleness and increasing ductility.

Assembly: The finished separate pieces put together according to the assembly drawing.

Base Circle: In the designing of gears, it is the circle on which the involute tooth is constructed.

Boring: A machine operation consisting of enlarging a hole to specified dimension with a boring tool.

Boss: A projection, usually cylindrical, on a casting or forging.

Broach: To finish the inside of a hole to a shape usually other than round with a long cutting tool which has a series of teeth that gradually increase in size.

Brown & Sharpe Taper: A taper system used in milling machine spindles and machine tools. Sizes are numbered and all have a taper of $\frac{1}{2}$ inch per foot except the No. 10 which is .5161 inches per foot.

Burnish: To polish to a smooth finish by working a smooth tool against moving or revolving surfaces.

Bushing: A metal sleeve or bearing upon which a pulley or wheel turns; a liner for a hole to make it smaller.

Carburize: To heat a low-carbon steel to approximately 2000° F for several hours in a box packed with carbonizing material, then allowing to cool slowly in preparation for heat treatment.

Caseharden: To harden the outer surface of carburized steel by heating to critical temperature and then quenching in oil or water.

Chamfer: The flat surface formed by cutting off a sharp corner, usually having an angle of 45°.

Chase: To cut threads in a lathe, as distinguished from cutting threads with a die.

Chatter: Noise produced by the rapid vibration of a machine tool against the work being machined.

Core: (1) That part of a mold which shapes the interior of a hollow casting. (2) The unaffected interior of a case hardened piece.

Counterbore: To enlarge an end of a hole cylindrically with a counterbore.

Countersink: To enlarge an end of a hole conically with a countersink.

Cutting Plane: An imaginary plane used to cut through an object to produce a sectional view.

Die: (1) One of a pair of hardened metal blocks or plates used to cut or form a required shape. (2) A tool for cutting external threads.

Die-casting: A method of producing castings to finished size by forcing molten metal into a suitable mold; an object or part formed by die-casting.

Dowel: A pin or other form of metal projection, anchored in one piece and fitting into a hole in an abutting piece to prevent motion or slipping, or to keep the pieces in their correct relative position.

Draft: The angle given a molding pattern to permit it to be withdrawn from the mold without disturbing the mold form.

Draw: (1) To stretch or shape metal by hammering. (2) To temper steel by gradual or intermittent quenching.

Drill: (1) To cut a cylindrical hole with a drill, usually a twist drill. (2) A pointed cutting tool rotated under pressure.

Drop forging: A shaped object formed between dies by the use of a drop hammer; the process of forging with a drop hammer.

Eccentric: Deviating from the center or from the line of a circle.

Elongated hole: A hole which is not completely circular by reason of the inserting of a flat area. Dimensioned by giving the radii of the two halves plus the dimension of the flat area.

Face: To machine a flat surface on a metal piece by means of a machine tool.

Fillet: A concave surface or filling at the intersection of two surfaces to provide increased strength.

Fin: A thin projecting edge on a casting or other metal surface.

Fit: The type and closeness of contact between two surfaces.

Forge: To shape hot metal by hammering or pressing a piece of metal which has been formed while hot.

Graduate: To mark in regular degrees of measurement, as in a scale or dial.

Grinding: A machine operation which consists of finishing a metal surface by means of abrasives.

Half Section: View in which cutting plane passes only half way through an object and one quarter is removed.

Horizontal: Parallel to horizon.

Hub: The central part of a wheel such as the part into which the spokes are inserted.

Jarno Taper: System of dimensioning tapers by diameter and length. The taper is .6 inch per foot in all sizes.

Jig: A fixture for locating, holding the work, and guiding the cutting tool in opera-

tions such as drilling, reaming, counterboring, and countersinking.

Kerf: The slit or groove produced in a piece of stock by a saw or cutting tool.

Key: A bar, pin, or wedge used to secure an object to a shaft to prevent relative movement between the two pieces.

Key Seat: The groove which holds the key in position, as in a shaft. To form a seat for a key by cutting.

Knurl: To roughen or indent a turned surface, such as a knob or handle, to produce a better hand grip.

Lap: A soft metal surface impregnated with fine abrasive for use in polishing operations. To finish by polishing with a lap.

Lug: A projecting piece through which something is attached, bears on, or passes.

Major Axis: The long diameter of an ellipse.

Major Diameter: The largest diameter of a screw thread.

Mill: To shape or dress metal by means of a rotary cutter on a milling machine.

Minor Axis: The shorter diameter of an ellipse.

Morse Taper: A system of standard dimensions for tapers, the taper being approximately 5/8 inch per foot. Used most commonly on taper shank drills.

Normalizing: Heat treatment of steel to improve grain and structure, performed by heating it above its critical temperature and then cooling in air.

Perpendicular: Lines or planes at a right angle to a given line or plane.

Picture Plane: An imaginary plane between the object and observer.

Piercing Point: The point at which a line or projecting element pierces a projection plane.

Pinion: The smaller of two mating gears.

Pitch: The distance from a point on one screw thread to a point on an adjacent thread taken along a straight line parallel to the axis of the thread.

Pitch Diameter: Diameter of an imaginary circle that would pass through a screw thread at such points as to make width of thread and width of space equal at point where they are cut by circle.

Principal View: The view of an object which shows the most detail and contour of the object. Example: Front view.

Profile: To machine an outline by moving a small rotating cutter usually controlled by a master cam or die.

Ream: A machine operation consisting of enlarging a hole slightly with a rotating fluted tool to provide greater accuracy.

Relief: A slight variance in the dimension of a machine part to allow for clearance.

Shear: To cut material by placing the material between two blades and exerting force on the blades in opposite directions.

Shim: A thin piece of metal placed between two parts to adjust the fit between the parts.

Slippage: Loss of motion in the transmission of power.

Spline: A projection on a shaft or hub which fits into a slot or groove of another part.

Spot face: To machine a round spot on a rough surface, usually around a hole to give a good seat to a nut or bolt.

Square: A four-sided figure having four equal sides and four right angles.

Straight Angle: An angle of 180^{o}.

Supplementary Angles: Two angles whose sum is 180^{o}.

Surface roughness: Roughness refers to the finely spaced irregularities produced in fabricating a part. The height of the irregularities is rated in microinches.

Tangent: A line drawn to the surface of an arc or circle so that it contacts the arc in only one point.

Tap: A machine tool for forming internal screw threads; to cut internal threads with the use of such a tool.

Taper: A uniform change in size.

Temper: To heat-treat hardened steel to make it harder by reheating it to below its critical temperature and allowing it to cool.

Template (or templet): A thin plate used as a guide for the form and shape of the piece to be made; also a gage for checking the form and shape of a piece.

Tolerance: Permissible variation in the size of a machined part, usually specified as a maximum, or upper limit, and a minimum, or lower limit.

Torque: Twisting force set up in or by a revolving shaft.

Triangle: A closed geometric figure having three sides and three angles:

1. Equilateral triangle: three sides and angles are equal.
2. Right triangle: one angle of the triangle is 90°.
3. Isosceles triangle: two sides are equal.

Turn: To shape a part by applying the cutting tool to the work while the work revolves on a shaft or spindle.

Waviness Height: Waviness refers to surface irregularities spaced too far apart to constitute roughness. Both height and width of waviness irregularities are rated in inches.